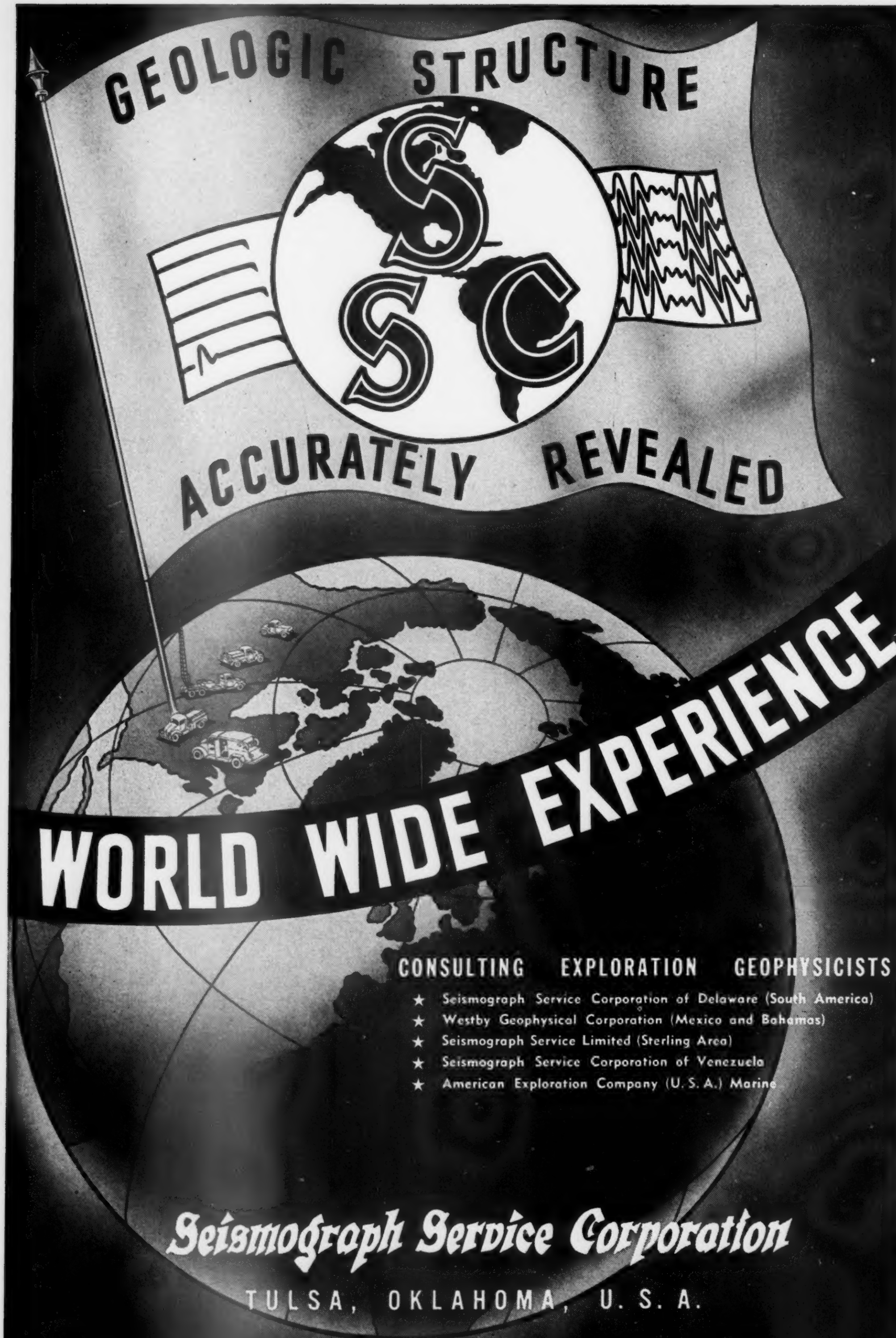
Volume 33 MAY, 1949 Number 5

BULLETIN
of the
American Association *of* Petroleum Geologists

CONTENTS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BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICE OF PUBLICATION, CHESTNUT-SMITH BUILDING, TULSA, OKLAHOMA

THE BULLETIN is published by the Association on the 15th of each month.

EDITORIAL AND PUBLICATION OFFICE AND ASSOCIATION HEADQUARTERS, Chestnut-Smith Building, 621 South Cheyenne Avenue, Tulsa, Oklahoma. Post Office, Box 979, Tulsa 1. Cable address: AAPEGOL.

BRITISH AGENT: Thomas Murby & Co., 40 Museum Street, London, W. C. 1.

SUBSCRIPTION PRICE to non-members is $15 per year (separate numbers, $1.50), prepaid to addresses in the United States; outside the United States, $15.40.

CLAIMS FOR NON-RECEIPT must be sent within 3 months of date of publication, to be filled gratis.

BACK NUMBERS, if available, may be ordered from Headquarters. Price list on request.

	Mem.	Non-Mem.
Cloth-bound Bulletin, Vols. 13 (1929)-15 (1931) incl., each	$5.00	$6.00

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Entered as second-class matter at the Post Office at Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1913.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

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Articles for June *Bulletin*

Annual Reviews of Exploration and Development in 1948

Volume 33 Number 5

BULLETIN
of the
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

MAY, 1949

PALEOTECTONIC AND PALEOGEOLOGIC MAPS OF CENTRAL AND WESTERN NORTH AMERICA[1]

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Ann Arbor, Michigan

ABSTRACT

A series of 12 paleotectonic maps and 5 paleogeologic maps presents the major stages of the evolution of the central and western part of the continent from early Paleozoic to late Mesozoic. They cover the western Cordillera from central British Columbia and Alberta, south to central Mexico, the central stable region east to Lake Michigan, and the Mid-Continent and part of the Gulf region. The tectonic maps show for each period or partial period of time: (1) the belts of severe compression and igneous activity; (2) the regions of epeirogenic uplift that were subjected to erosion; (3) the areas which received less than 1,000 feet of sediments; and (4) the basins and troughs which subsided and received more than 1,000 feet of sediments. The basins and troughs, where possible, are contoured on 1,000-foot intervals. In summary, the tectonic maps show the crustal movements for each period. Tectonic elements are emphasized whereas the paleogeographic map emphasizes shore lines, and commonly obscures the tectonic elements.

The series of paleogeologic maps starts with the outcrop pattern of the continent at the close of the Devonian, and presents views of its developing complexity at the close of the Lower Pennsylvanian, the Permian, the Triassic, and the Jurassic. Both the tectonic and geologic maps seem necessary to gain an adequate understanding of the major geologic elements of the continent and the way they evolved.

In some areas much detail had to be generalized; in others, hazardous interpretations had to be drawn. The purpose is to present the maps as preliminary copies, and to ask for assistance in correcting and adding to the data they show.

INTRODUCTION

The paleotectonic and paleogeologic maps presented have been under preparation for several years in connection with a course on the geology of North America at the University of Michigan. The central and western parts of the continent are shown by the maps but the eastern part is not yet well enough in hand to be included. The maps are considered preliminary copies though they are the final efforts of the writer, on the basis of the published record. The purpose is to present them and ask for assistance in correcting and adding to the data they show. Petroleum geologists have unpublished information that may necessitate changes, and also certain publications may have been overlooked.

The maps portray the major tectonic and sedimentary elements of the con-

[1] Read before the Association at Denver, April 26, 1948. Manuscript received, October 11, 1948.

[2] Professor of structural geology, University of Michigan.

tinent in the order of development, and serve as guides for the teaching of regional geology. In addition, they will serve the economic geologist who is intent upon finding the valuable materials from all parts of the continent and in reviewing prejudices that have eliminated certain areas and stratigraphic sequences from due consideration. It is hoped he will be able to add many details to the framework they afford.

CHARACTERISTICS OF DIFFERENT MAPS

PALEOGEOGRAPHIC MAPS

The paleogeographic map, familiar to geologists, shows the seaways of a particular time. The shore lines are the focal point of interest. Commonly so much attention has been given to the location of the shore lines and the connection of seas because of similar faunas and floras, that tectonic features have been lost in part or overlooked. On some maps the postulated connections have been drawn across major tectonic elements, blanking them out entirely, where perhaps the seas had only infrequent or shifting passageways across them. If the patterns of some regional paleogeographic maps are studied, little specific structural significance is realized. This is because the thickness of the sediments is not shown, and 100 feet of strata appears undifferentiated from 10,000 feet. It has been said that in order for a paleogeographic map to be correct it must be a snapshot of the ever shifting seas that invaded the continent, and that this precision is not possible. It must not be inferred, however, that the construction of paleogeographic maps is futile, because many have been successfully made, and they have certainly helped to shape our knowledge of an evolving continent. They do, however, center attention on the shore lines of the moment.

Other attributes of a growing continent deserve as much attention as the shore lines, perhaps more. These are the nature and thickness of the sediments deposited in a span of time, the areas that were uplifted epeirogenically and subjected to erosion, and the belts of severe crustal deformation. Also the relation of any sea to those that preceded should be illustrated, and the time and spatial relations of the great overlaps or unconformities should be shown. In an attempt to picture these features the paleotectonic and paleogeologic maps on the following pages have been worked out.

PALEOGEOLOGIC MAPS

A paleogeologic map shows the areas of outcrop of the various rock units at some time in the past. After considerable experimentation it seems most instructive in view of existing information to construct five paleogeologic maps, one at the close of the Devonian, one at the close of Lampasas time in the Pennsylvanian, and one at the close of the Permian, Triassic, and Jurassic. By the close of the Cretaceous the detail becomes too complicated to record on a page-size map, and also the pattern would be similar to that of the geologic map of the present, except for the Tertiary orogenic belts and basins.

Because of the page size of the maps and because they picture only the major geologic events, the great stratigraphic systems are represented by single patterns. The Middle and Upper Ordovician and Silurian are shown together as a single unit. The Cambrian and Lower Ordovician (Arbuckle limestone and equivalents) are also shown by one pattern because the greatest unconformity within the two systems is post-Arbuckle.

No attempt is made to detail the orogenic belts because the necessary information is not available. They are belts of considerable or great complexity, and in places during certain time intervals suffered continued deformation, so that their condition at precise times is impossible to ascertain. They are shown, therefore, in one pattern. The early history of some, such as the Ouachita and the Pacific belts, is known only by deduction, and even in showing approximate position, let alone internal details, the procedure is wrought with uncertainty.

The parts of the paleogeologic maps that are nearest correct are those of former outcrops now buried beneath younger deposits, and known through extensive drilling. As long as buried, a contact is fixed in its position at the time of burial. The combined activity of several thousand geologists working over a period of 50 years in the Mid-Continent and the Plains states has unfolded a remarkable panorama of deformation, erosion, and overlap, and it represents one of the great achievements in science. In regions like the Canadian Shield, the minimum extent of Ordovician, Silurian, or Devonian overlap at present is fairly well known, but since these systems were not covered, their fronts have been receding, and where the contacts stood at various times in the past is uncertain.

Not only the distribution, past and present, is a key to the construction of paleogeologic maps, but the nature of the deposits is also of critical significance. Coarse and thick conglomerates commonly reveal the margins of vigorously uplifted landmasses, and the great volcanic assemblage of sediments are diagnostic of orogenic belts.[3]

The paleogeologic maps picture the great overlaps or unconformities in unusual clarity, and have this advantage over paleogeographic or paleotectonic maps.

Where the word system appears on the paleogeologic or paleotectonic maps it denotes mountain system, not stratigraphic system.

TECTONIC MAPS

The paleotectonic maps are intended primarily to represent the deformation of part of the earth's crust during certain time intervals, whereas the paleogeologic maps are photographs, so to speak, at several times as the train of deformational, erosional, and depositional events proceeded. Twelve tectonic maps are presented. Each map shows the orogenic belts that were active during the

[3] A. J. Eardley, "Paleozoic Cordilleran Geosyncline and Related Orogeny," *Jour. Geol.*, Vol. 55, No. 4 (1947).

time specified, the areas of epeirogenic uplift and depression, and the major faults if outside the belts of severe compression. The orogenic belts are those of severe compression and igneous activity. The areas of epeirogenic uplift are recognized as those that were lifted above the sea and subjected to erosion. They are generally the arches, domes, and older orogenic belts. The areas that were epeirogenically depressed are the shelves and basins within the central stable region, and the older orogenic belts that underwent regional subsidence. The areas of sedimentation are divided in two parts, those that received less than 1,000 feet of sediments and those that received more. The sediments more than 1,000 feet thick are contoured at 1,000-foot intervals. An index to the amount of subsidence during a certain time is taken as the thickness of the sediments that accumulated. This is obviously an approximation because subsidence may have been more rapid than sedimentation with resulting deep water, or contrariwise, the sediments may have built above sea-level. Also compaction is not considered in isopaching the basins; the original thickness was greater than now. Isopaching the basins is at least free from interpretation of the depth of deposition and the amount of compaction, answers to which are generally not procurable. However, contouring on the basis of thickness is revealing, if only in a relative way, of the position and magnitude of the troughs, basins, shelves, and platforms. If an unconformity records the removal of part or all of a sequence of beds, an attempt has been made to estimate the original thickness by comparison with surrounding normal thicknesses.

Each paleotectonic map records solely what happened during the time which it represents. If an uplift such as the Pennsylvanian and Permian Colorado Range of the Ancestral Rockies remained above water, but was not again uplifted in the Triassic, it is not shown as an area of uplift on the paleotectonic map of the Triassic. In the case of a basin that continued to subside through several periods, only the amount of subsidence is shown on the paleotectonic map that occurred in the time interval that the map represents. Since the tectonic and sedimentational events of greatest importance in one region did not occur at the same time as those in another, and since the logical time to picture the geology of an area is near the close or slightly after the major disturbances, it is evident that many maps will result. The problem is to reduce to a minimum the number necessary to show the major events of the great region concerned. In doing so, it may not be possible to portray minor events in certain areas. Only their gross effects can be illustrated. For instance, if the existence of several disconformities in a basin within a partial period of time has been demonstrated, and if it has been decided to construct *one* tectonic map for the time interval of these several breaks, only the net subsidence can be shown, although both up and down movements of the crust have occurred in the basin during that time.

It has recently been pointed out[4] that a succession of unconformities in sediments flanking a belt of orogeny may represent continuous deformation in the mobile belt, and not a number of spasmodic episodes. The Cretaceous orogenic

[4] James Gilluly, presidential address, Geol. Soc. America, November, 1948.

belts of the Rocky Mountains are particularly representative of this theory.

The twelve paleotectonic maps presented depict the deformation and sedimentation which determined the patterns arrested by the five successive paleogeologic maps.

SOURCES OF DATA

The data from which the maps were prepared come almost entirely from the published record. Unpublished information has been contributed by only a few geologists who have discussed the maps with the writer. Present published information is adequate to decipher the major tectonic features and for the preparation of the maps, except in certain areas of extensive metamorphism and blanketing extrusive rocks.

Original stratigraphic correlations were made only where necessary. Authority for correlation was accorded the charts prepared by the Committee on Stratigraphy of the National Research Council, and published in the bulletins of the Geological Society of America.

METHOD OF PRESENTATION

The maps are presented in chronological order with fairly lengthy titles to describe the chief structural and sedimentary characteristics. One, two, or three paleotectonic maps precede each paleogeologic map, and portray the crustal movements that resulted in the outcrop pattern of each paleogeologic map.

Discussion of evidence for the features of each map will appear in a later publication.

DESCRIPTION OF MAPS

FIGURE ONE

The Cordilleran geosyncline in Cambrian, Ordovician, and Silurian time was one of great subsidence, the Cambrian strata alone having a thickness of 15,000 feet in southern Nevada and southern California. The western part of the geosyncline consists of an assemblage principally of lavas, pyroclastics, conglomerates, graywackes, black shales, massive limestones and cherts, all of which indicate the proximity of a volcanic archipelago on the west. The metamorphism of the volcanics and sediments, and the unconformities within them, represent fairly continued orogeny in the volcanic belt.[5] The eastern troughs of the geosyncline were filled with sandstones, shales, limestones, and dolomites, derived from the central part of the continent.

The basin of subsidence in Arkansas, Oklahoma, and Texas, through the present sites of the Ouachita, Arbuckle, and Wichita mountains, differed from the Cordilleran in being smaller, shallower, and evidently intracontinental in not having volcanic materials which are characteristic of bordering geosynclines.[6]

[5] A. J. Eardley, "Paleozoic Cordilleran Geosyncline and Related Orogeny," *Jour. Geol.*, Vol. 55, No. 4 (1947).

[6] Marshall Kay, "North American Geosynclines—Their Classifications," *Bull. Geol. Soc. America* (abstract), Vol. 56 (1945), p. 1172.

———, "Geological Nomenclature and the Craton," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 31 (1947), pp. 1289–93.

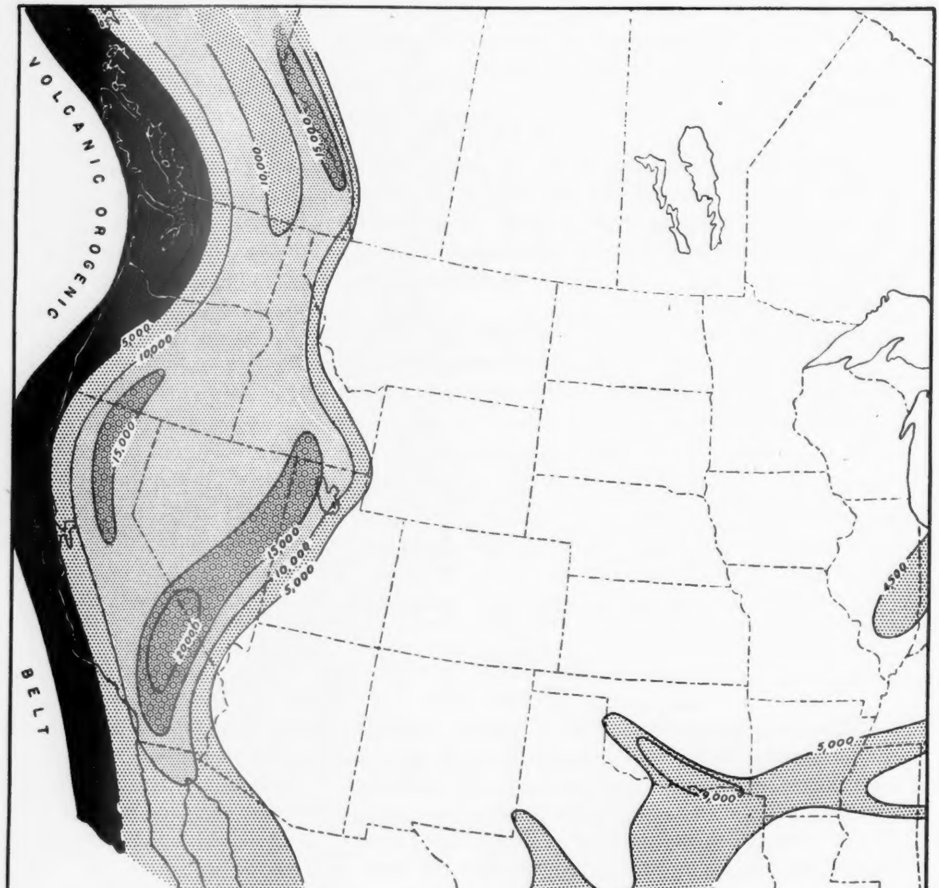

FIG. 1.—Pre-Devonian Paleozoic basins.

This is especially true of the trough in southern Oklahoma, where the Arbuckle limestone is more than 6,000 feet thick.

FIGURE TWO

During Devonian time the Trans-Continental arch rose, and strata previously deposited across its site were removed at the close of the period, except for the Colorado and Arizona sags where 100–200 feet of beds remained.

Great transverse arches also developed. The Cambridge-Ellis-Chautauqua-Ozark uplift extended from eastern Montana to southern Missouri and beyond, around the south end of the Illinois-Indiana-Kentucky basin to the Nashville dome, and thence northward to the Cincinnati dome. The Concho arch in central Texas is on a southeastward projection of a transverse element from New Mexico. Small uplifts that pre-date the Chattanooga shale in the area of the Arbuckle Mountains and Hunton arch of south-central Oklahoma may be projections of a belt of deformation on the southeast and represent early orogeny in the Ouachita Mountains. Llanoria is a theoretical land from which much sediment is supposed to have been derived that was deposited in the site of the present Ouachita Mountains. Whether it was an orogenic belt or resistant landmass is problematical, and where it lay in the Early and Middle Paleozoic is conjectural; in fact, some geologists doubt that it existed.

The Cordilleran Devonian basin was broad and centered in Nevada where the most complete Devonian section in North America is found. On the west lay the volcanic archipelago that supplied abundant volcanics, graywackes, conglomerates, and black shales to the adjacent seas.

FIGURE THREE

The outcrop pattern at the close of the Devonian which resulted in response to the movements shown in Figure 2 is one of considerable simplicity. It reveals particularly the Upper and Middle Ordovician overlap on the Lower Ordovician and Cambrian, and also on the pre-Cambrian, and the Devonian overlap on all older rocks in several places. It also shows the prominence of the great Trans-Continental arch, and the approach to bilateral symmetry of the continent at the time.

The arch was not high enough to furnish coarse clastics to the bordering seas. Fine clastics and chemical precipitates in them attest a low terrane with sluggish drainage.

The major unconformity within the Cambrian and Ordovician systems is post-Arbuckle and pre-St. Peter, and in order to show the overlap without the multiplication of maps it is necessary to include the Lower Ordovician Arbuckle and Ellenburger limestones of Kansas, Oklahoma, and Texas and the pre-St. Peter Ordovician strata of the Great Lakes with the Cambrian under one pattern.

Comparison of Figure 3 with Figure 2 shows that the areas of uplift are not everywhere lacking in Devonian strata, namely, northwestern Colorado, northeastern Utah, southwestern Utah, western New Mexico, and eastern Colorado.

FIG. 2.—Paleotectonic map of Devonian. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

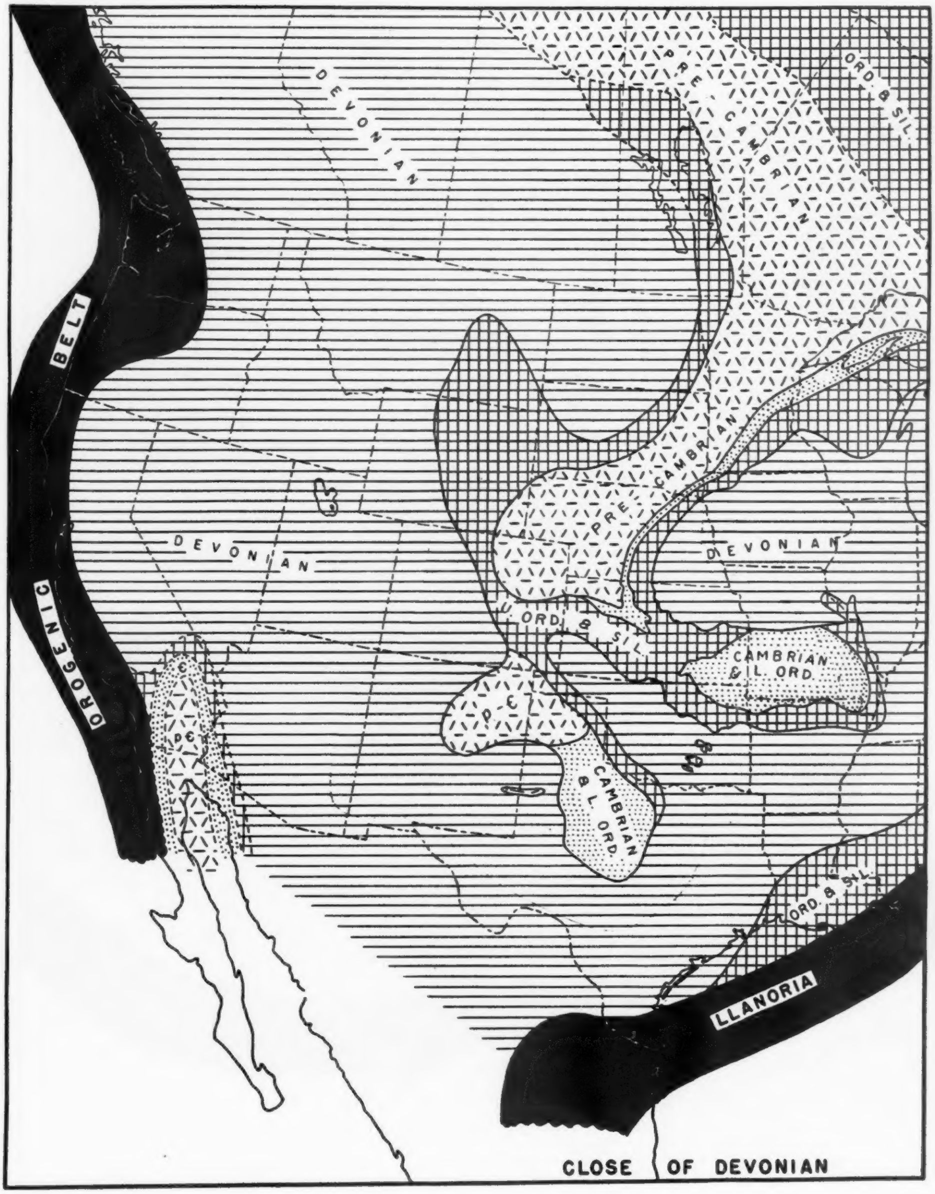

FIG. 3.—Paleogeologic map at close of Devonian.

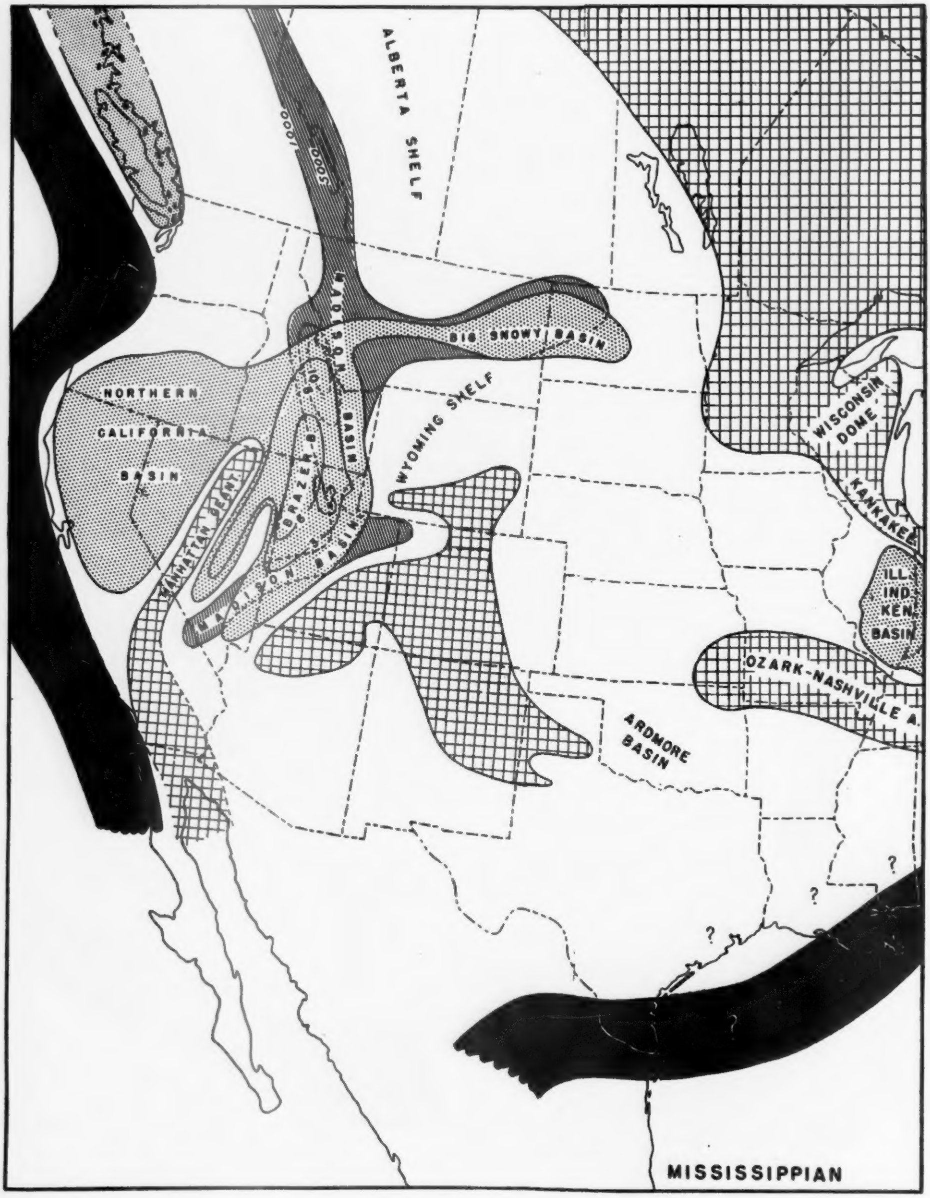

FIG. 4.—Paleotectonic map of Mississippian. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet and received more than 1,000 feet of sediments.

These are areas of Devonian subsidence and deposition, but near the close of the Devonian, of gentle uplift and erosion.

FIGURE FOUR

Mississippian seas were widespread and in the Rocky Mountain region a long narrow zone subsided in Lower Mississippian to form the Madison basin. Subsidence exceeded 5,000 feet along the Idaho-Montana and British Columbia-Alberta boundaries. A long eastward basin sank through central Montana, and continued to sink in Upper Mississippian time; it is known as the Big Snowy basin. The Upper Mississippian basin in Idaho and Utah is known as the Brazer basin, and it sank more than 6,000 feet in western Utah. A broad basin of poorly known limits extended through northern California, southern Oregon, and northwestern Nevada west of the Manhattan geanticline. The amount of subsidence is unknown. The rise of the Manhattan geanticline in central Nevada marked the beginning of division of the great Cordilleran geosyncline into a western trough and an eastern trough.

The Trans-Continental arch sagged gently through its central area and was covered, but by the close of Lower Pennsylvanian time it had risen enough to have been eroded, and the pre-Cambrian was again exposed (Fig. 6). The Concho arch was covered in central Texas and the Ozark-Nashville arch was severed from the Trans-Continental arch.

FIGURE FIVE A

In earliest Pennsylvanian time a deep and probably large basin sank rapidly in eastern Texas, southern Oklahoma, and western Louisiana and received about 17,000 feet of clastic sediments known as those of Ouachita facies. As the basin sank, an uplift on the north rose in which thrusting brought sedimentary rocks of Arbuckle facies to exposure. The area of the uplift soon sagged and it was covered by sediments of Atoka age (map 5B).

The Lasalle anticlinal belt first began to rise at the close of the Mississippian and continued to grow during the Pennsylvanian. It split the Illinois-Indiana-Kentucky basin in two parts.

FIGURE FIVE B

The south-central part of the continent was one of considerable and widespread unrest in Lower Pennsylvanian, and ranges and basins were formed. The Wichita Mountain system of Oklahoma and northern Texas was uplifted together with the Ancestral Rockies of New Mexico and Colorado. The Concho arch was elevated again but on a much restricted scale, and the Pecos Range in West Texas appeared. The long, narrow Nemaha range and a northern branch, the Abilene, rose sharply, and at the same time basins on the east sank. The previously formed LaSalle anticlinal belt was mostly buried.

The trough of the deep basin in eastern Texas of earliest Pennsylvanian time shifted northward to central Arkansas, and more than 10,000 feet of sediments (the Atoka formation) accumulated.

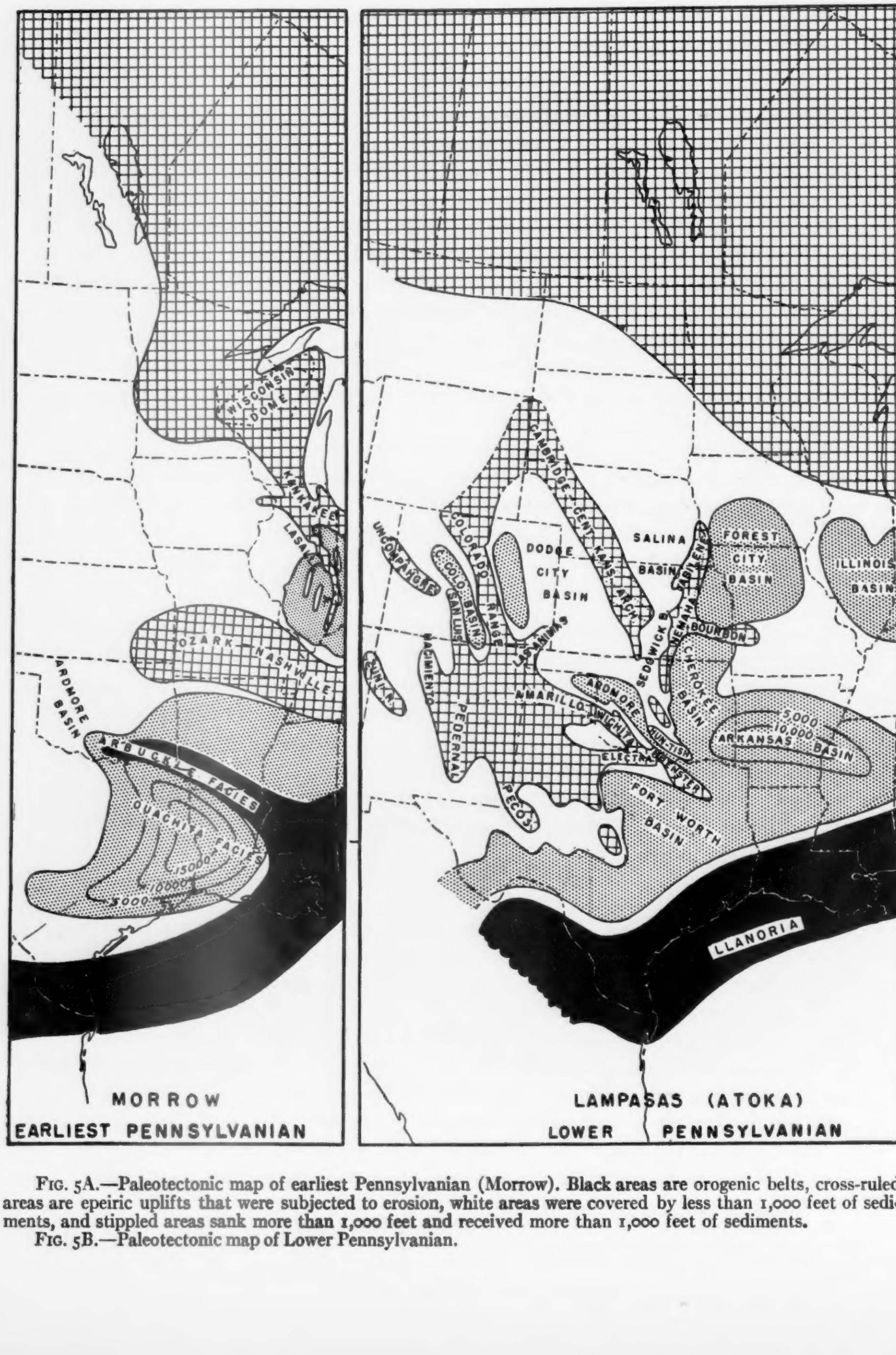

FIG. 5A.—Paleotectonic map of earliest Pennsylvanian (Morrow). Black areas are orogenic belts, cross-ruled areas are epeiric uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet and received more than 1,000 feet of sediments.

FIG. 5B.—Paleotectonic map of Lower Pennsylvanian.

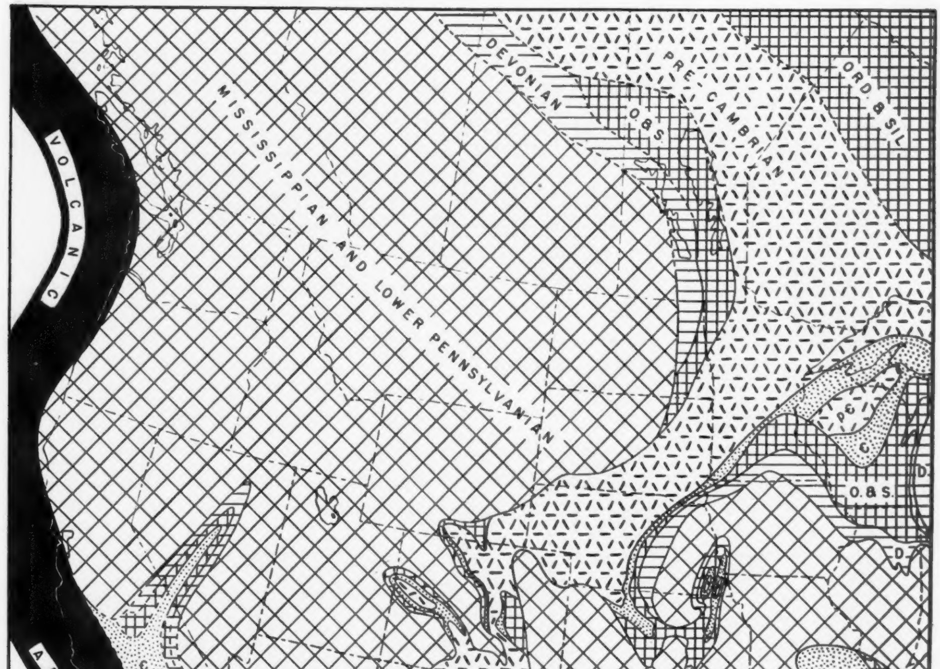

FIG. 6.—Paleogeologic map at close of Lower Pennsylvanian (Lampasas).

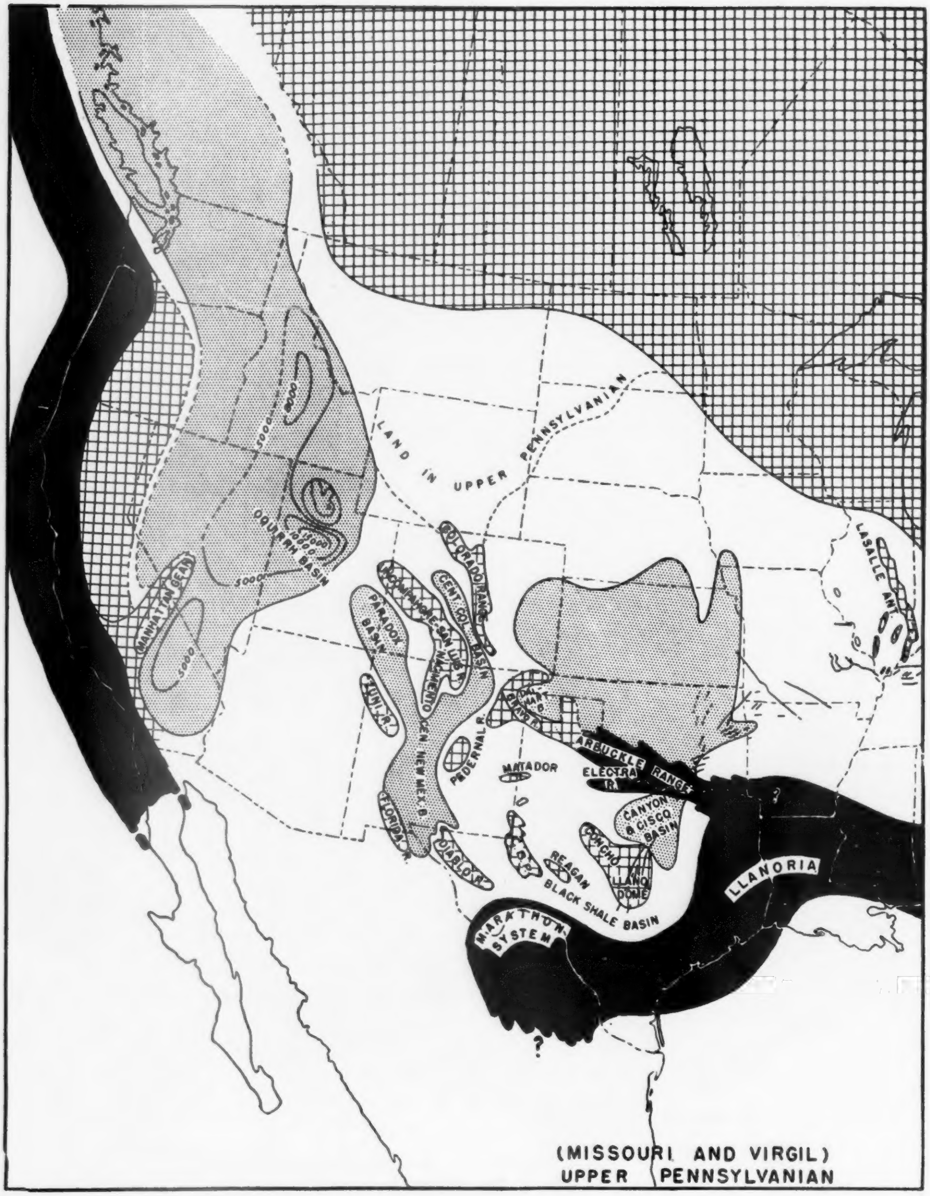

FIG. 7.—Paleotectonic map of Upper Pennsylvanian. Entire Pennsylvanian of Rocky Mountain geosyncline represented. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

As the Pennsylvanian strata are poorly divided in the Rocky Mountain region, all the Pennsylvanian movements there are shown on the Upper Pennsylvanian map (Fig. 7), and only the Lower Pennsylvanian movements of the south-central part of the continent are on this map (5B).

FIGURE SIX

In spite of the Mississippian and Lower Pennsylvanian activity shown in Figures 4, 5A, and 5B, the Devonian outcrop pattern was still dominant at the close of Lower Pennsylvanian. The new ranges, uplifted in the basin areas, impressed sharp, new details on the pattern, but those that rose in the pre-Cambrian areas left no reflection on the geologic map. They are known from their relief beneath the Upper Pennsylvanian and Permian beds.

The Trans-Continental arch remained, in general, above sea-level but was overlapped in places by the Mississippian and Lower Pennsylvanian deposits. The Ozark dome was extensively transgressed by the seas.

The volcanic orogenic archipelago persisted along the west margin of the continent, and was the source of volcanic contributions to the sediments of the adjacent seas, and the cause of unconformities and low-grade metamorphism in the deposits.

The map depicts the outcrop pattern at the close of Lampasas (Atoka) time in the Mid-Continent region but a slightly later time, early Des Moines, in the region of the Ancestral Rockies.

FIGURE SEVEN

Extensive subsidence occurred during the Pennsylvanian in the Cordilleran geosyncline with the deposition of more sand than in any time since the Cambrian. A local basin in west-central Utah subsided greatly and was filled in one place with 25,000 feet of beds. If the volcanic orogenic belt of western United States persisted it evidently was separated by a piedmont from the seaway because the western sediments are not coarse. The Manhattan geanticline continued to rise.

The Ancestral Rockies were elevated again in Upper Pennsylvanian with changes that more clearly defined them in characteristic form, and the Florida range probably appeared for the first time. The Arbuckle Mountain system was formed by considerable compression of the sediments of the Ardmore basin and pressed tightly against the early Wichita range. An extensive area of Lower Pennsylvanian beds was gently elevated and subjected to erosion in Wyoming and Montana so that when the Permian sediments were spread out in the region they covered the Lower Pennsylvanian. The Lasalle anticlinal belt had its second and main growth.

The Marathon orogeny of West Texas occurred in Upper Pennsylvanian time and several thrust sheets were pressed northward against a buttressing foreland. The great thickness of Lower Pennsylvanian beds of the Ouachita region may already have been caught in compressive forces; in fact, some believe that the

FIG. 8.—Paleotectonic map of Permian. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

main deformation occurred in mid-Pennsylvanian. The Arbuckle belt of compression is shown as an appendage of the Upper Pennsylvanian Ouachitas, but the main thrusting is pictured in the Permian (Fig. 8).

A belt of high-angle faults developed approximately parallel with the orogenic belt. It extended from the Llano dome to the Ozark dome and eastward into Tennessee and Kentucky.

FIGURE EIGHT

A deep broad trough developed along the Pacific and was filled largely with volcanic materials. The Permian was a time of most extensive volcanism, and the site of maximum subsidence and fill later became the locale of the great Nevadan batholiths. The Manhattan geanticline had shifted slightly eastward and now separated a small deep trough on the east in Utah, filled with the mainland assemblage of sandstones, shales, and limestones, from the volcanic assemblage on the west. Extensive shelf seas stretched eastward and southward from Idaho and Utah.

The Ouachita Mountain system possibly received its greatest compressional growth at this time, and the southern basin facies (Ouachita facies of Figure 4) was thrust in several sheets into contact with the northern basin facies (Arbuckle facies of Figure 4), and this in turn against the Arkansas basin beds shown in Figure 5. The thrust sheets of the Ouachitas bring rocks of dissimilar character nearer and perhaps across those of the Arbuckles.

Another salient of the compressional belt was active in Coahuila where only small areas of it are exposed to-day. The previously compressed Marathons were elevated epeirogenically, and in front of them several basins sank to considerable depth. The platforms of little subsidence between were the sites of the previous Pecos and Diablo ranges. The Anadarko basin also subsided appreciably.

A group of great faults, in part high-angle, in part, perhaps, low-angle thrust, occurs in the western part of the Lake Superior region. They are probably post-Devonian in age and have been assigned to the Permian, but poorly fit the structural or paleogeographic pattern of the time.

The Colorado and Uncompahgre ranges of the Ancestral Rockies remained as elevated areas but are not shown on this map because the uplift occurred in Pennsylvanian time.

FIGURE NINE

The crustal movements and spread of seas in the Upper Pennsylvanian and Permian profoundly altered the geologic outcrop pattern of the continent. The greatest change came from the extensive overlap of the pre-Middle Pennsylvanian structures by the Upper Pennsylvanian and Permian sediments. All the Trans-Continental arch southwest of Wisconsin was buried, the structures of Kansas and parts of the Ozark dome, the Wichita and Arbuckle mountain systems, and the ranges of West Texas vanished beneath the deposits. Only the Colorado and Uncompahgre ranges of the Ancestral Rockies remained visible,

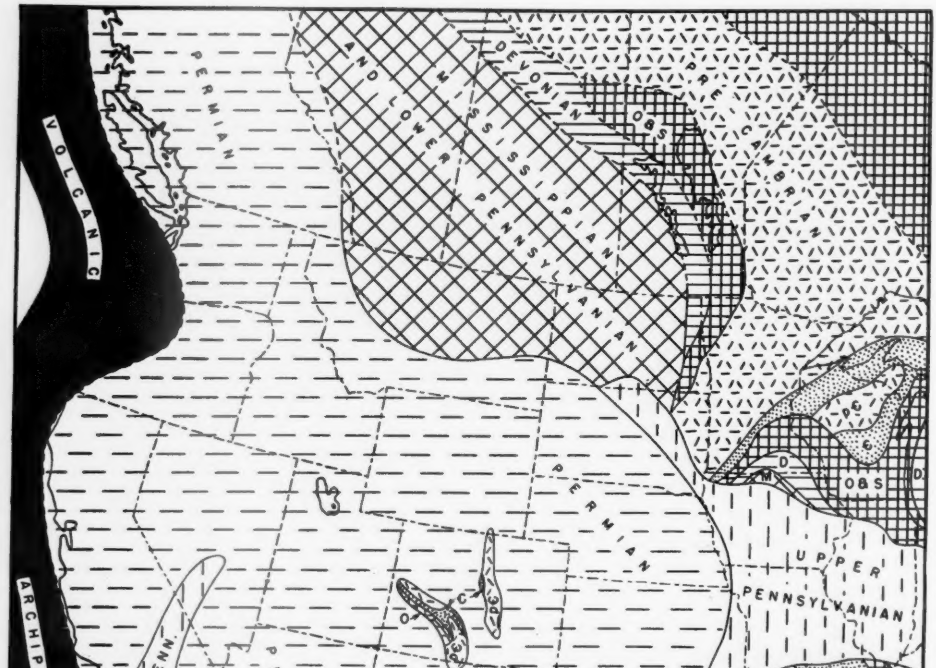

FIG. 9.—Paleogeologic map at close of Permian.

not because of renewed uplift but because of considerable relief inherent from their original development.

The map shows the most extensive time of Permian overlap before the compression of the Coahuila system and the epeirogenic uplift of the Marathons (Fig. 8).

The many Carboniferous ranges of the south-central part of the country were reduced in elevation somewhat before final burial, their own waste that bordered them contributing to the process; but it was material from the distant Canadian Shield and the Marathon-Ouachita orogenic belt that eventually overwhelmed them.

FIGURE TEN

The Manhattan geanticline developed northward into Canada and was land except for a passageway in Nevada to the Utah trough where continued subsidence somewhat enlarged the Permian basin, and more than 2,000 feet of marine limestone, shale, and sandstone accumulated. East of the trough the Triassic deposits are largely continental and red in color. The geanticline, later known as the Cordilleran, bounded a deep western trough where again a dominant part of the fill was volcanic material. The west-flanking archipelago of volcanoes and orogeny apparently continued from the Paleozoic into the Mesozoic.

FIGURE ELEVEN

The Triassic deposits are generally within the boundaries of the Permian except in western Mexico where a basin of considerable size developed. A long, broad arch rose through southwestern Arizona and presaged the position and direction of future orogeny.

The Coahuila-Marathon-Ouachita orogenic belt was still mountainous and had a broad piedmont generally free of deposits. The mountainous belt may have risen gently as its rocks were eroded and carried away, but orogeny there had ended.

The Colorado and Uncompahgre ranges still stood as islands in the surrounding deposits but are not shown on the tectonic map (Fig. 10) because they were not sites of local uplift in the Triassic.

FIGURE TWELVE

The Cordilleran geanticline became complete in the Lower Jurassic and separated a western trough effectively from an eastern trough. The western trough again was one of extreme subsidence, and 30,000 feet of volcanics, black shale, and other sediments accumulated in it. The eastern trough was one generally of marine transgression and deposition, but the Lower and Middle Jurassic deposits are much less extensive than the earlier Permian, Triassic, and the later Upper Jurassic and Cretaceous deposits.

The greater part of the continent was undergoing erosion in Lower and Middle Jurassic time. The volcanic archipelago at this and other times is viewed as one of frequent or continuous seaway passages across it, and a route of nearshore and land-animal migration with frequent interruptions.

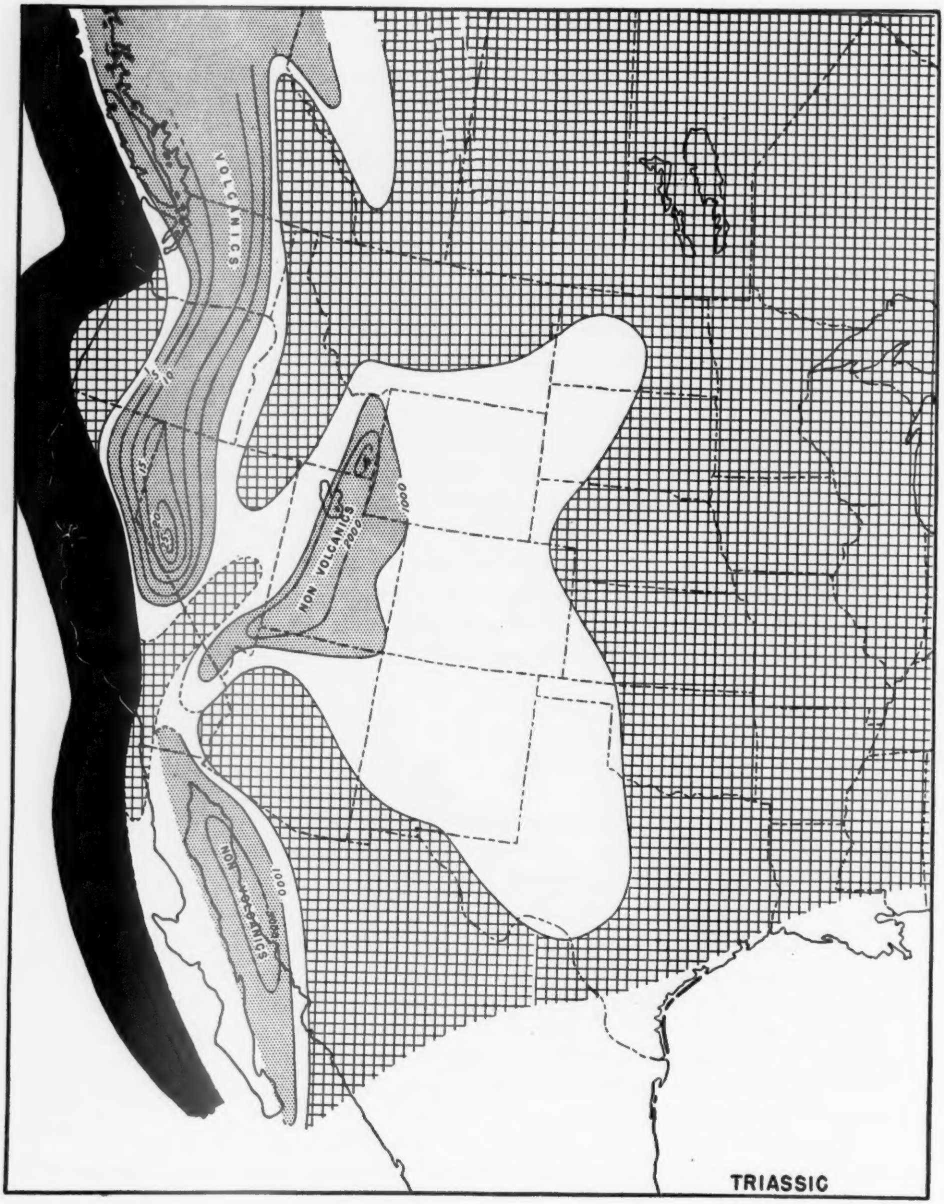

FIG. 10.—Paleotectonic map of Triassic. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

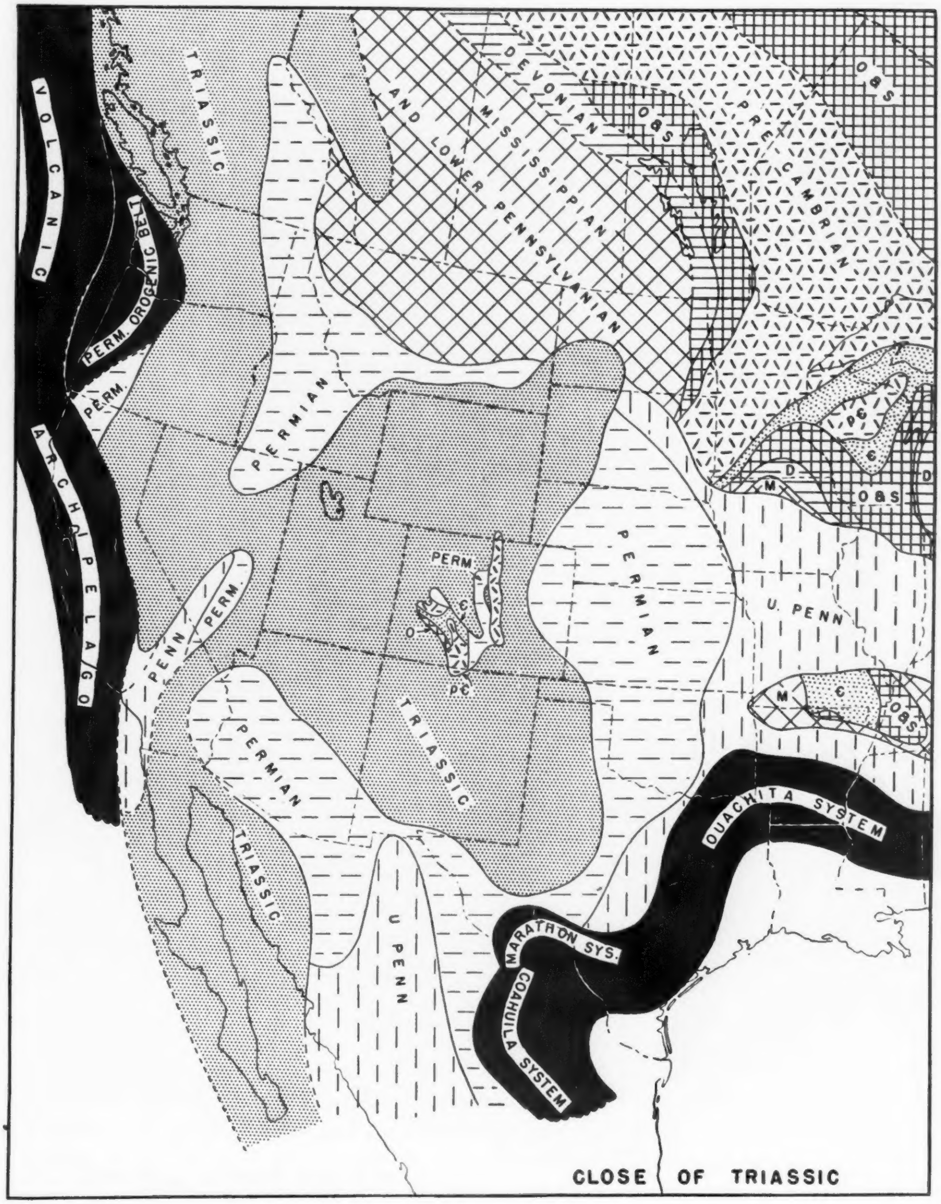

Fig. 11.—Paleogeologic map at close of Triassic.

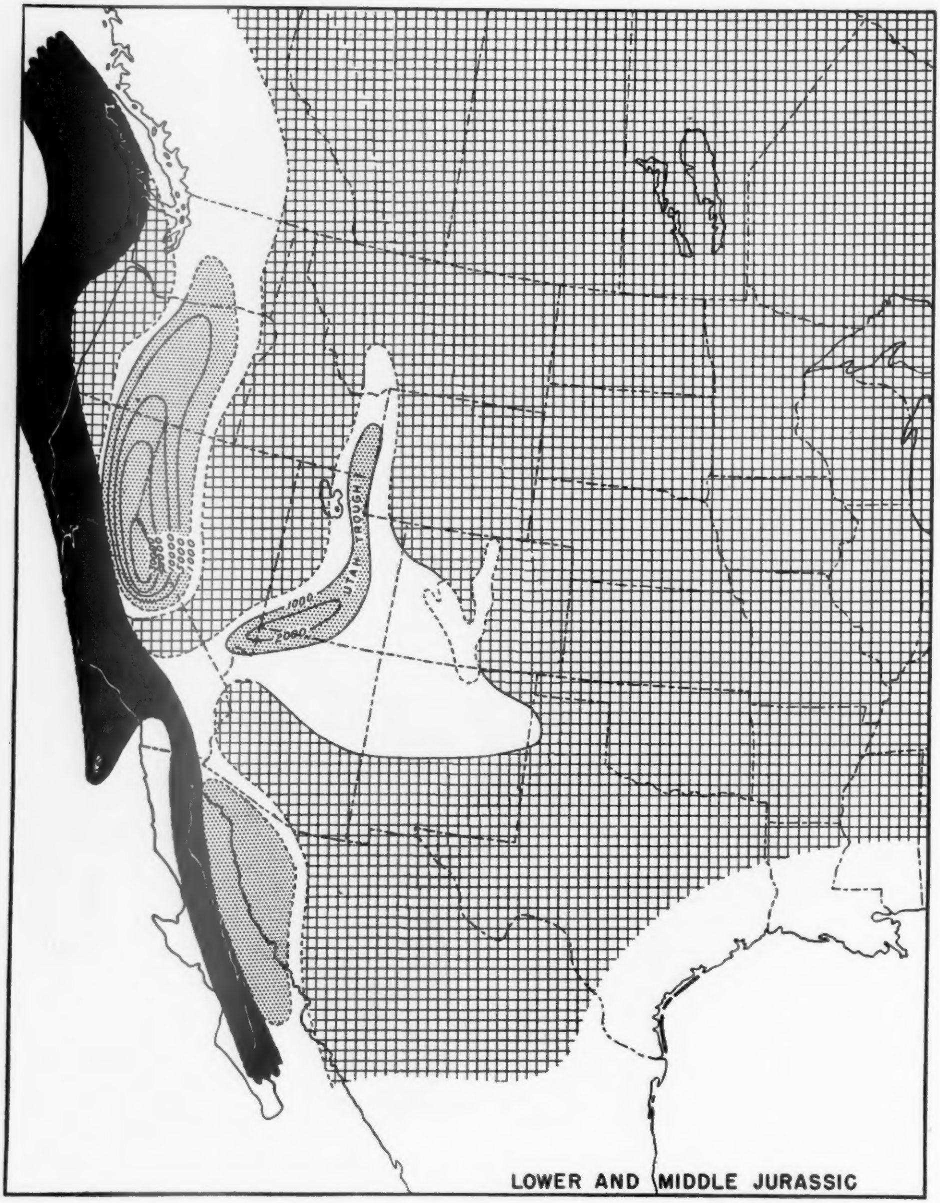

FIG. 12.—Paleotectonic map of Lower and Middle Jurassic. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

Beds in the Rocky Mountains which are considered late Middle Jurassic (Bathonian) by Imlay are not included on this map, but are added to those of the Upper Jurassic of the next map. They are thin and are more closely related lithologically to Upper Jurassic formations.

FIGURE THIRTEEN

In the Upper Jurassic occurred the most profound of western crustal disturbances, the Nevadan orogeny. Following abruptly after Kimmeridgian time of the Upper Jurassic, the Paleozoic, Triassic, and Lower and Middle Jurassic rocks of the western Cordilleran trough were tightly compressed and then injected by great batholiths. During the compression, isoclinal near-vertical folds were formed with low-grade metamorphism throughout. The manner of batholithic emplacement is still not clear, but remnants of the isoclinally folded sequences, in places much injected, form giant septa in the batholiths. A great mountain system was created, and on the west a new trough began to subside which received in excess of 20,000 feet of sediments (Franciscan and Knoxville) in Portlandian and Tithonian time, before the close of the Jurassic. The sediments that filled the trough came both from the west and the east, and a new volcanic belt was established on the west.

The Utah trough again sank and received 10,000 feet of sediments, mostly shales and sandstones, but also in part, an evaporite sequence. The shelf sea spread over most of the Rocky Mountains and Great Plains states.

The Mexican geosyncline began to form. It was separated by a peninsula, the Coahuila, from the seas of the Gulf of Mexico which represent the first known invasion of the Paleozoic Ouachita orogenic belt (or the ancient land of Llanoria).

FIGURE FOURTEEN

The Nevadan orogenic belt, the new, late Jurassic trough on the west, and the farther west-lying volcanic belt are shown. The Jurassic overlap on the Paleozoic strata of Montana, Alberta, and Saskatchewan, particularly on the Mississippian, is striking.

The Colorado Ancestral Rockies still stand as islands, although more overlapped than before.

The Coahuila Peninsula (Fig. 13) is made up mostly of the Coahuila and Marathon orogenic belt, and the Ouachita Mountain system is extensively overlapped from the south by the Upper Jurassic deposits.

FIGURE FIFTEEN

The Cordilleran geanticline in the Lower Cretaceous was composed principally of the Jurassic Nevadan orogenic belt and a new belt of moderate orogeny. The eastern front of the new belt from Idaho northward is marked by gravels and coarse sands. The California trough continued to sink rapidly and received at least 25,000 feet of sands and shales. The Nevadan batholithic cycle had not ended with the Upper Jurassic intrusions; in southern California and the peninsula of Lower California, great batholiths were emplaced in Lower Cretaceous time and perhaps as late as Middle Cretaceous. The same is true for the great

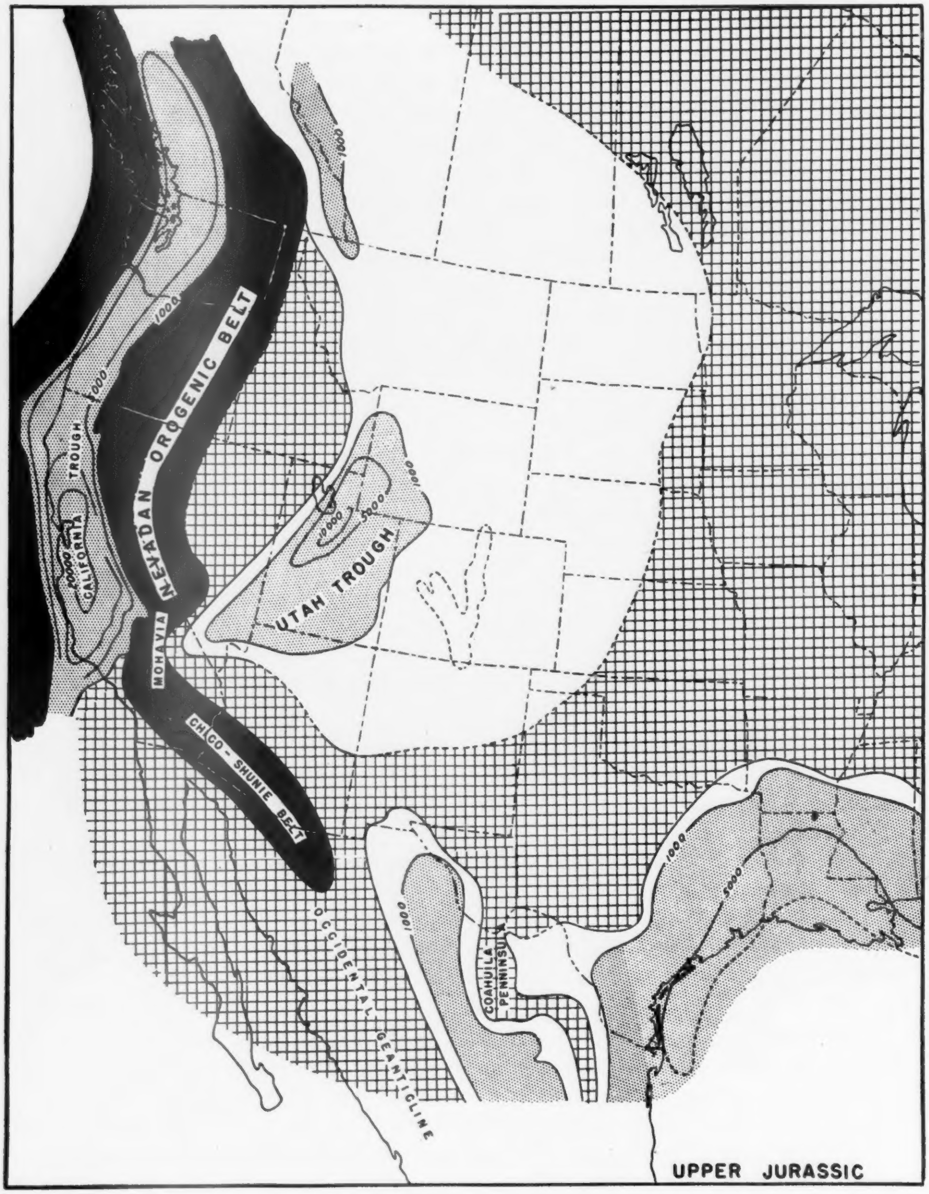

FIG. 13.—Paleotectonic map of Upper Jurassic. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

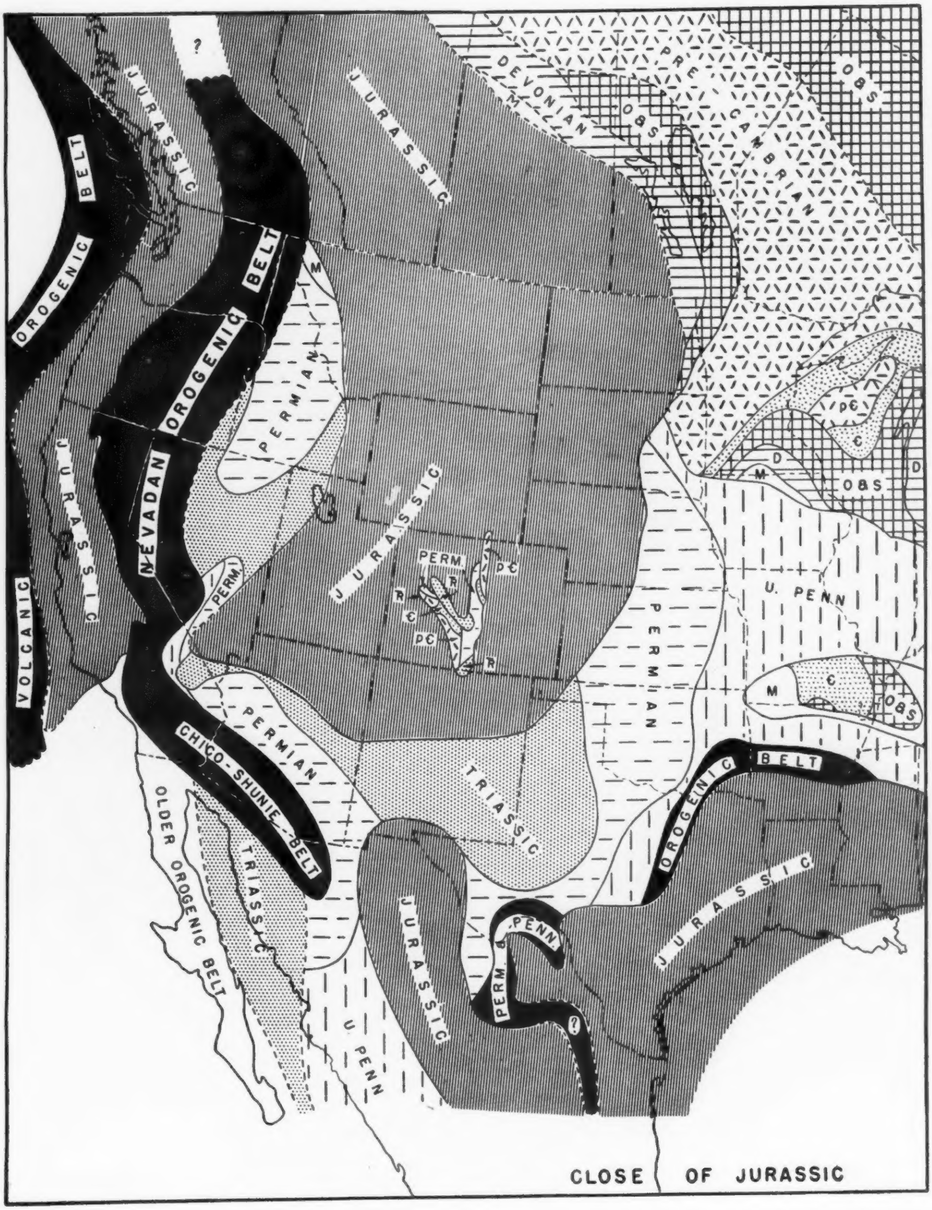

FIG. 14.—Paleogeologic map at close of Jurassic.

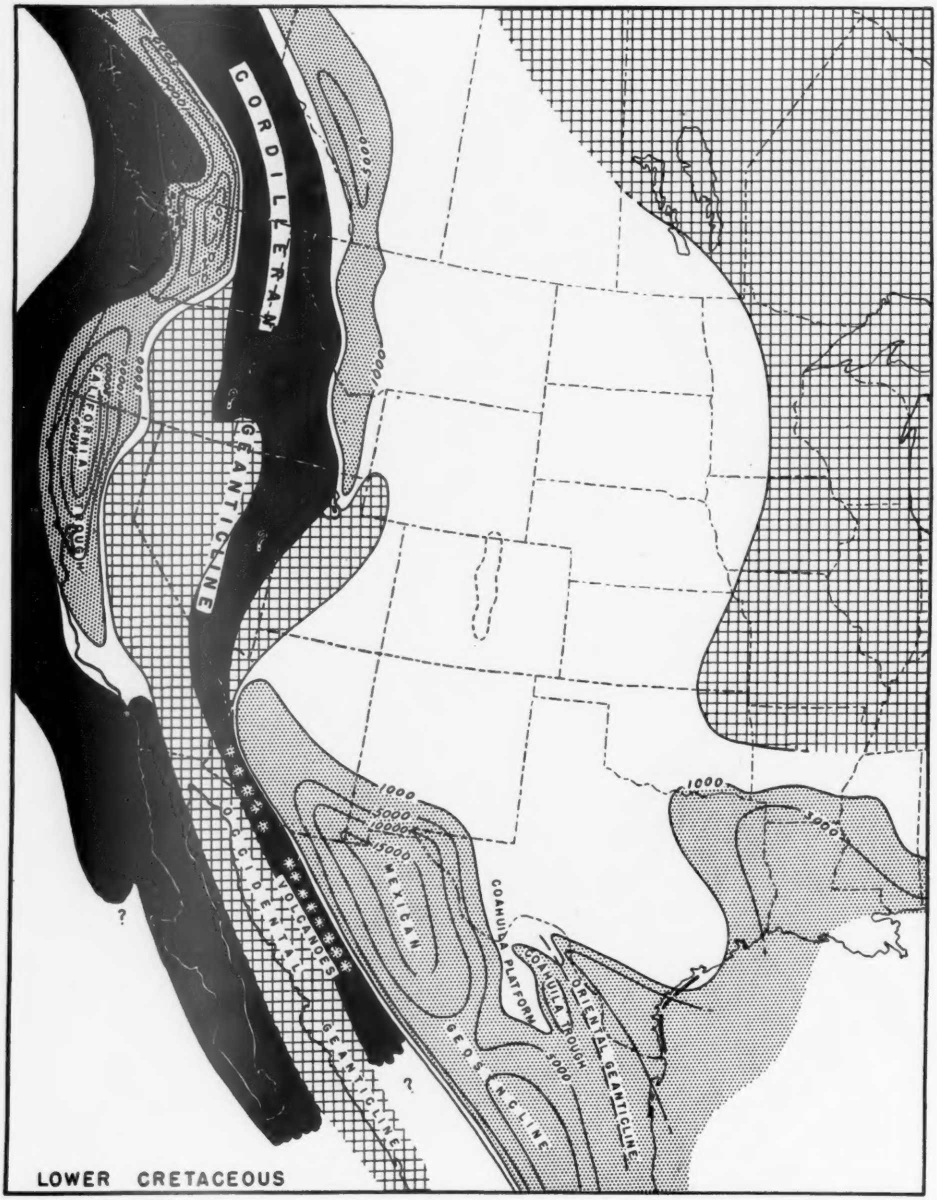

FIG. 15.—Paleotectonic map of Lower Cretaceous. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

FIG. 16.—Paleotectonic map of Upper Cretaceous. Black areas are orogenic belts, cross-ruled areas are epeirogenic uplifts that were subjected to erosion, white areas were covered by less than 1,000 feet of sediments, and stippled areas sank more than 1,000 feet, and received more than 1,000 feet of sediments.

batholith of British Columbia and the batholiths along the International Border in British Columbia, Washington, and Idaho. The Idaho batholith is also shown as originating at this time, although it may have developed as late as the Upper Cretaceous.

The southern part of the continent was a scene of much activity. The Mexican geosyncline enlarged and sank more than 15,000 feet. It received considerable volcanic material from the west. The seas spread over the Coahuila Peninsula to make a platform, and were more extensive over the southern and western part of the country than at any previous Mesozoic time.

FIGURE SIXTEEN

Widespread crustal unrest marked Upper Cretaceous time. The California trough was divided into two parts by an uplift, Salinia, and another uplift, Klamathonia, separated the basin in northern California from a basin in Oregon and Washington. Thick deposits in the California trough reveal exposure of the batholith in the Sierra Nevadas. Activity in the Cordilleran geanticline centered along its eastern margin in early Upper Cretaceous, and thick, coarse conglomerates were deposited in a subsiding trough, particularly in central and north-central Utah. This belt was probably one of continuing orogeny during most of the Upper Cretaceous time, and possibly connected through southern Nevada with one in western Mexico.

The Mexican geosyncline had shrunk and changed decidedly from its Lower Cretaceous form. A trough extending from southeastern Arizona into northern Mexico contains much coarse conglomerate and volcanic material. South of the Coahuila platform a deep east-west trough, the Parras, sank and received more than 15,000 feet of sediments, mostly limestones and shales.

The Upper Cretaceous seas and deposits were even more widespread over the Rocky Mountains and Great Plains states than those of the Lower Cretaceous, and the deposits were much thicker. East of the deep troughs, that had successively sunk in central Utah, only thin deposits had previously accumulated under shelf sea conditions. Now sediments in excess of 5,000 feet thick collected over a wide area of the shelf. Actually in the late Upper Cretaceous from Pierre through Fox Hills and Lance time, a group of ranges began to rise from the Utah-Wyoming shelf, and nestled between or adjacent to them, fairly deep basins sank and trapped much sediments. The north end of the ancient Colorado Range, which had never quite been buried, was uplifted, together with the Uinta, Wind River, Sweet Water, Beartooth, Bighorn, and possibly Black Hills ranges. This activity was the harbinger of the widespread, and in places intense, Laramide orogeny that followed. The early uplifts of the ranges noted were followed by several others with their own details, all of which imparted the structural form they have to-day.

The geologic stage is now set for the Paleocene and Eocene phases of the Laramide orogeny and the later Tertiary disturbances that left their impress from the Pacific to the Great Plains.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 683-694, 1 FIG.

GEOLOGY OF GREEN AND YAMPA RIVER CANYONS AND VICINITY, DINOSAUR NATIONAL MONUMENT, UTAH AND COLORADO[1]

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ABSTRACT

The Green and Yampa River Canyon country within the boundaries of Dinosaur National Monument represents the deeply dissected eastern end of an east-west anticlinal fold, the Uinta Mountains, and its accompanying smaller flank folds. Oldest formation exposed in this area is the Uinta Mountain group (Algonkian) and the youngest, Browns Park formation (Pliocene). Along the crest of the main arch, in the deeper canyons, and at some places along the upthrown sides of faults are exposed massive dark red blocky-weathering quartzitic sandstone, shale, and conglomerate beds of the Uinta Mountain group, and the shale and quartzitic sandstone beds of the Lodore formation (Cambrian). In much of the area, Mississippian, Pennsylvanian, and Permian rocks form long dip-slopes toward the south.

Typical of Uinta Mountain structure and representative of the smaller folds that flank the main arch of the Uinta Mountains is the Split Mountain-Yampa Plateau area. Formations along the crest of this anticlinorium have low attitudes in contrast to the sharply flexed, steeply dipping, younger flanking formations. These strata with their well developed flat-iron and race-track patterns of exposure exhibit a striking, colorful geological cross section ranging in age from Lower Pennsylvanian (Morgan) to Upper Cretaceous (Mancos). Lower Pennsylvanian and Lower Mississippian are exposed in the deeper part of Split Mountain Canyon.

High-angle normal faults occur in the Monument area. The Split Mountain-Yampa Plateau section is traversed by the Yampa fault which seems to die out in the western part of the fold. Split Mountain Canyon has been carved by the Green River along the western end of this zone.

Stream piracy and deep entrenching of the meandering stream courses during Pleistocene have produced a spectacular scenic area.

INTRODUCTION

The work discussed was begun in the spring of 1943 as an aid to basic planning and interpretation relative to the future development of Dinosaur National Monument. Proposed dams to be constructed within the Monument, namely, those at Echo Park and Split Mountain Canyon, resulting in the submergence of more than 100 miles of canyon country along the Green and Yampa rivers, were an additional incentive for making this investigation.

Shortly after this work was initiated, major exploration of the Rangely oil field and contiguous areas south of the Monument, in Colorado, was begun. Because the same formations being drilled in this field are so well exposed in the Dinosaur National Monument, the writers' preliminary studies at that time served to orient many of the newly arrived geologists.

DISCOVERY OF DINOSAUR QUARRY AND CREATION OF MONUMENT

On August 19, 1909, Professor Earl Douglass' (Carnegie Museum) discovery of dinosaur remains near Split Mountain Canyon, Green River, formed the basis

[1] Preliminary report on this region. Manuscript received, November 15, 1948.

[2] Utah Field House of Natural History. The writers wish to express appreciation to chief naturalist John E. Doerr and C. Max Bauer of the National Park Service, Lloyd G. Henbest, John B. Reeside, Jr., and J. Steele Williams of the United States Geological Survey, G. Arthur Cooper of the United States National Museum, and Christina Lochman, paleontologist, for helpful suggestions and for assistance in fossil determinations.

for the famous Dinosaur Quarry, which, in 1915, was included in the original 80 acres proclaimed as Dinosaur National Monument, Uintah County, Utah. Because of the scenic and recreational values of the adjoining Green and Yampa river canyons, the monument was extended in 1938 to its present size of slightly more than 200,000 acres. As now constituted, it is located in northeastern Utah and northwestern Colorado, the larger part in Colorado.

STRUCTURE

The eastern end of the Uinta Mountain arch and its minor flank folds comprise the main structural features of Dinosaur National Monument. These folds represent part of an original geosynclinal trough into which were deposited sediments from possibly Algonkian to late Cretaceous time. That the Uinta depositional basin was an east-west arm of the Wasatch trough is shown by the merging of the two folded areas, similarity in some of the lithologic character and stratigraphic breaks in the western part of the range, and by thickening of many of the sediments in a westerly direction. Both trough areas were part of the great Rocky Mountain geosyncline. Elevation and folding of these depositional basins at the close of the Cretaceous period produced, among other ranges, the Uinta Mountains, the principal east-west-trending range in the western hemisphere. The average height is between 8,000 and 9,000 feet. The western half has many peaks more than 13,000 feet in elevation, highest of which is Kings Peak, 13,498 feet, located west of the center of the range. Maximum elevation within the Monument area, Zenobia Peak, Douglas Mountain, on the east end of the Uintas, is 9,006 feet. The axis of the range is slightly north of the center. It pitches downward at both ends and is somewhat convex northward and asymmetrical. A broadening occurs on the east end where there are more parallel flank folds. This structural broadening, together with thinning of many of the formations eastward and a generally lower elevation of the range in the east, is indicative of a shallowing of the Uinta trough in that direction.

The northward convexity of the Uintas suggests a greater stress from a southerly direction. High land areas on the south may have supplied the Uinta trough with some of its sediments. Heaton[3] has shown that the presence of the "Nevada Mountains" on the west and southwest and "Cascadia" on the northwest, both positive areas during much of the time the Rocky Mountain geosyncline was receiving sediments, probably contributed much of this material. This conclusion is substantiated by the westward thickening of many of the formations.

Some of the smaller structures, such as the Split Mountain-Blue Mountain anticline (Yampa Plateau) within the Monument boundary, pitch at moderate angles in a westerly direction. The formations are relatively flat on the crests of the anticlines and are very sharply flexed on the flanks of these folds, commonly

[3] Ross L. Heaton, "Ancestral Rockies and Mesozoic and Late Paleozoic Stratigraphy of the Rocky Mountain Region," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, No. 2 (February, 1933), pp. 1–68.

steepened by drag folding along faults, exhibiting the typical Uinta Mountain structure.

Faults are numerous throughout the area and are chiefly of the normal type. Some of them are distributive in character and are part of a larger system of faulting, such as the Yampa fault zone. They commonly occur as strike faults, but in some places they are diagonal in direction and rotational in habit. The maximum displacement along these high-angle faults in the Monument area is 4,300 feet. Such a displacement occurs along the Yampa fault proper in the Johnson Draw area near Tanks Peak, south rim of the Yampa Canyon, where Lower Triassic beds are in fault contact with Algonkian.

STRATIGRAPHY

GENERAL STATEMENT

The formations within Dinosaur National Monument range in age from Algonkian (Uinta Mountain group) to Pliocene (Browns Park formation). They are sedimentary and largely of shallow marine deposition. Along much of the Green and Yampa River Canyon country, Carboniferous formations with low south dips are well exposed on broad, gentle dip slopes. Along smaller anticlines, such as in the Split Mountain area, formations range in age from Mississippian (Madison dolomite) to Upper Cretaceous (Mancos shale). The erosion of this arch and the steep attitude of its flanking formations (with dips up to 67°) produce a spectacular and colorful geologic cross section, particularly well developed in the headquarters area of the Monument.

With the exception of Pliocene (Browns Park formation) and Miocene (Bishop conglomerate), no other Tertiary sediments are represented in the Monument. However, outside the boundary, on the south and west, Eocene (Wasatch, Green River, and Uinta formations) and Oligocene (Duchesne River formation) are widespread and well exposed.

In the northeast corner of the Monument, the Browns Park formation (dip 3° northwest) lies on the Uinta Mountain group (dip 8° southeast) with angular discordance, and brings the youngest and oldest formations in contact. In the Red Creek and Jesse Ewing Canyon sections (Wheeler and Goslin mountains), near the Browns Park settlement, Archean (Red Creek quartzite) with its hornblendic and micaceous schists and pegmatitic dikes occurs north of the Monument boundary. With the exception of these pegmatitic intrusives and a small amount of lava (largely andesitic) on the west end of the range, the rocks of the Uintas are sedimentary.

The only angular break noted, other than that between Pliocene and Algonkian, is a possible slight discordance of 4° or 5° observed in one or two places between the Lodore formation (Cambrian) and the Uinta Mountain group (Algonkian), and is probably only local. A pronounced erosional unconformity occurs between these two formations in the upper end of Whirlpool Canyon of the Green River.

TABLE

GENERALIZED COLUMNAR SECTION* GREEN AND YAMPA RIVER CANYONS AND VICINITY DINOSAUR NATIONAL MONUMENT

SYSTEM	SERIES	GROUP	FORMATION	COLUMNAR SECTION	THICKNESS	CHARACTER OF THE SEDIMENTS
QUATERNARY	Recent Pleistocene		Quaternary Alluvium		0-50	Stream gravels and boulder mantle which cap many of the hills and benches on the lower mountain slopes. Composed largely of older rocks of the range and represents in part reworked Bishop and Browns Park conglomerates.
			Unconformity			
TERTIARY	Pliocene		Browns Park		1200	Friable chalk-white to grayish cross-bedded sandstones, in part tuffaceous. Lake, fluviatile and some eolian deposits. Also cherty sandstones and chert beds and concretions. A basal conglomerate composed of conglomeratic sandstone and quartzite from the Uinta Mountain group.
			Unconformity			
TERTIARY	Miocene		Bishop (?) Conglomerate		0-100	A poorly-sorted conglomerate consisting of sand, pebbles and boulders which attain a diameter of several feet. Composed in large part of red sandstone and quartzite of the Uinta Mountain group. Also gray and red limestones, sandstones and cherts of the Pennsylvanian and Mississippian. Occasionally schists, pegmatite and grayish quartzite from the Archean (Red Creek) occur.
			Unconformity			
CRETACEOUS	Upper Cretaceous	Mancos Group	Mancos Shale		5000	Consists principally of dark carbonaceous shales that weather light gray to yellowish buff and form soft clay deposits Calcite geodes common. Thin sandstone lenses. Cephalopods and pelecypods are fairly abundant. Presence of alkali minerals renders water impotable. Shallow oil production at Rangely.
CRETACEOUS	Upper Cretaceous	Mancos Group	Frontier		200	Buff marine and continental calcareous sandstone containing pelecypods, shark teeth, plant remains. Carbonaceous shale and sub-bituminous coal beds. Siliceous sandy shale at base.

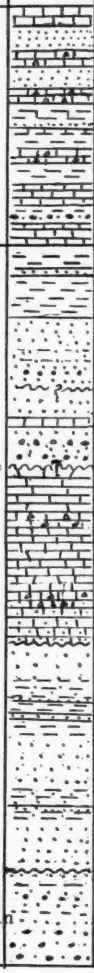
* This section not drawn to scale. Space does not permit the showing of this great thickness of deposits to scale in graphic form where descriptions of the formations are combined in the same chart.

SYSTEM	SERIES	GROUP	FORMATION	COLUMNAR SECTION	THICKNESS	CHARACTER OF THE SEDIMENTS
CRETACEOUS		Mancos Gr.	Mowry		125	Dark hard siliceous marine shale that weathers silver-gray and contains abundant fish scales. A few feet of darker bafter shale beneath may represent a thin layer of Thermopolis.
CRETACEOUS	Lower Upper	Dakota Group ?	Dakota Sandstone		48	Yellowish cross-bedded sandstone and conglomerate at top. White and black chert and gray limestone pebbles less than one inch in length. Calcite seams are abundant. Carbonaceous shale streaks occur.
CRETACEOUS	Lower?	Dakota Group ? Cloverly ?	Fuson Sh.		36	Dark gray to reddish shale
CRETACEOUS	Lower?	Dakota Group ? Cloverly ?	Lakota Sandstone		18	Yellowish siliceous (quartzitic) sandstone Both sandstone members carry fossil wood
		Unconformity				
JURASSIC			Morrison		756	A succession of varicolored marls, siltstones and brownish cross-bedded poorly-sorted conglomeratic sandstones carrying abundant dinosaur remains, silicified wood and fresh-water clam shells. "Rainbow beds." Occasional limestone and chert layers. Geodes and concretions are common. A series of lake, stream, flood-plain and possibly delta deposits. May include some wind-blown sand.
JURASSIC	Upper Jurassic	San Rafael Group	Curtis		260	Greenish gray glauconitic quartz sandstone at base; shales and oolitic sandy limestones in upper part. Marine pelecypods gastropods and cephalopods in upper two thirds of the formation.
JURASSIC	Upper Jurassic	San Rafael Group	Entrada		165	Light gray to buff and pink medium-grained uniform quartz sandstone. Eolian. No fossils observed. Smooth dome-weathering.
JURASSIC	Upper Jurassic	San Rafael Group	Carmel		125	Red siltstone and shale. Marine pelecypods abundant north of Vernal (outside monument). Also gypsum. Thins eastward and becomes more arenaceous. Occasional three-toed dinosaur tracks.
		Unconformity?				

TABLE I (*continued*)

SYSTEM	SERIES	GROUP FORMATION	COLUMNAR SECTION	THICKNESS	CHARACTER OF THE SEDIMENTS
JURASSIC	Middle?	Glen Canyon — Navajo		700	Buff to red uniform strongly cross-bedded medium-grained sandstone. Eolian. Basal layers probably waterlain and contain occasional 4-toed dinosaur tracks. Sandstone and limonite concretions.
		Unconformity			
TRIASSIC	Upper	Chinle		230	Predominately red shales, marls and siltstones of fresh-water origin. Ripple marks and mudcracks. Phytosaur teeth and bone fragments and amphibian bones in lower varicolored shales. Calcite geodes abundant. A 20-foot layer of white sandstone occurs in the upper third of the formation. A small amount of fine conglomerate. Silicified wood.
TRIASSIC	Lower Upper?	Shinarump		45	Light buff to yellowish fluviatile conglomerate and coarse sandstone containing quartz, quartzite and chert pebbles of various colors, usually under 2 inches in length. Silicified wood common. Basal conglomerate of the Chinle?
		Unconformity			
TRIASSIC	Lower	Moenkopi		800	Brick-red gypsiferous calcareous shales and siltstones. Reptilian tracks probably Chirotherium.
PERMIAN		Park City (Phosphoria)		50	Light gray thinly-bedded fossiliferous limestone, calcareous sandstone and gray red and yellowish shale. Marine. Green to purple calcareous and siliceous geodes. Phosphate not well developed in the monument area, but is of high commercial value north of Vernal where the formation is much thicker. Hydrocarbon streaks.
PENNSYLVANIAN	Upper — Des Moines	Weber		1000	White to light gray or buff uniform fine-to medium-grained siliceous and calcareous sandstone. Massive. Probably marine. Cross-bedded. Poor cementation in most areas favors rapid erosion producing rugged canyon country. "Ribbon" staining on canyon walls. The principal producing formation in the Rangely Oil Field.

TABLE I (*continued*)



SYSTEM	SERIES	GROUP FORMATION	COLUMNAR SECTION	THICKNESS	CHARACTER OF THE SEDIMENTS
PENNSYLVANIAN	Middle: Des Moines, Atoka; Lower: Morrow	Morgan		1281	Gray, often cherty, limestones weathering red alternate with thick fine-grained white to terra cotta red sandstone beds in upper third of the formation. Mauve calcareous shales (marlstones) and limestones, occasionally cherty, occupy middle portion. Cherty limestones, darker in color, occur in the lower section. Brachiopods, corals, bryozoa, foraminifera, and other forms abundant.
?	?	?		185	Black carbonaceous shale containing light-colored plant-bearing quartz sandstone is underlain by white to yellow quartz sandstone, medium- to fine-grained and often containing thin carbonaceous streaks. Also a thin layer of fine conglomerate with hematitic cement. Some limestone and red (hematitic) angular conglomeratic sandstone occur at base.
		Unconformity?			
MISSISSIPPIAN	Lower	Madison		600	Buff to dark gray porous, shattered and fetid limestones and dolomites. Sandy at base. Some gray to pink chert. Occasional fossiliferous layers. Cup corals, colonial corals, Euomphalus, brachiopods and occasional trilobite pygidiums.
		Unconformity			
CAMBRIAN	Upper	Lodore		350-400	White to red coarse poorly-sorted quartzitic and in part arkosic sandstones at top, middle and base. Middle layer is very glauconitic. The sandstone members are separated by 2 layers of silty shale containing thin sandstone beds which are frequently somewhat glauconitic and fossiliferous. Occasional trilobites and very small brachiopod and gastropod forms.
		Unconformity			
ALGONKIAN		Uinta Mountain Group		12,600 ±	Red to white coarse quartzitic, in part arkosic, sandstones and conglomerates. Some thin shale beds. Bleach spots common.

TABLE I (*continued*)

The Uinta Mountain group crops out chiefly along the crest of the main Uinta arch, and occurs in the smaller folds only where erosion has exposed it in the deeper parts of canyons, and along the dissected upthrown sides of faults.

Like the Algonkian, the Cambrian beds are also exposed in the deeper canyons and along some of the faults. Such an exposure is found in Jones Hole along the Island Park fault. Here the Cambrian (Lodore formation) consists of approximately 400 feet (maximum for the Monument) of white to red predominantly coarse quartzitic sandstones at the top, middle, and base of the formation, and with thin sericitic silty shale partings. The middle sandstone member is extremely glauconitic in part. The base of the upper sandstone contains casts of small trilobites, chiefly the cephalons. Separating these sandstone layers are two principal sericitic silty shale beds, predominantly green in color, and containing thin sandstones, some of which are glauconitic. In the spring of 1945, the writers found a few trilobites in the upper part of the top shale which has a thickness of 60 feet. Although not identifiable specifically, these forms were considered by G. Arthur Cooper and Christina Lochman[4] as Upper Cambrian in age, and thus the Lodore formation may be assigned to this period. The writers are still seeking better material. Small shell forms resembling *Billingsella* and *Dicellomus* (brachiopods), specimens of *Hyolithes* (pteropod), and one form resembling tiny coiled gastropods are common in some sandy layers throughout the upper half of the formation. A brownish black shell-stone layer, 1–2 inches thick, occurs midway in the upper shale. Also, structures similar to "Cruziana" (an undetermined organism) and "*Paleophycus*" (seaweed-like impressions) occur in the green and red silty shales. Mud cracks and ripple marks are abundant. The upper 45 feet of the basal sandstone member contains 28 feet of red to white "vermicelli" sandstone with some purple and green sericitic, and ripple-marked shale partings. The spaghetti-like rods may represent concretions or casts of worm borings.

Other very well represented systems are Mississippian, Pennsylvanian, Permian, Triassic, Jurassic, and Cretaceous. Formations representing these periods are widespread and well distributed throughout the Monument. Absence of Ordovician, Silurian, and Devonian beds suggests non-deposition inasmuch as the basal layers of the Madison contain sandy streaks which resemble material in the upper part of the Lodore formation. This material consists of poorly sorted clear to pink quartz grains concentrated along minute ripple-marked surfaces and cross-bedding planes. The presence of these sand grains in the basal layers of the Madison suggests derivation, in part, from the Lodore on which they rest. No pronounced erosional unconformity has been observed between the Lodore and Madison, although a great time break occurs between the two formations.

Except for the somewhat sandy limestone at the base of the Madison beds (Lower Mississippian), the rest of the formation in this area consists chiefly of massive, cliff-forming, medium to coarse dolomites and limestones, some of which contain pink to black and white banded chert. Some of the dense, tan limestone

[4] Personal communication.

in the upper part of the formation is considerably shattered. There is some limestone breccia in the lower part. This formation is quite porous, in part the result of partial dissolution of small fossils, such as minute cup corals, especially in some of the lower layers. The lack of arenaceous material suggests deep-water origin and uniform conditions of deposition during Madison time in this area. The Pennsylvanian sediments (Morgan formation), however, indicate more variable conditions.

Between the Morgan and Madison formations occur 90 feet of carbonaceous shale containing in the upper part a 4-foot quartz-sandstone layer bearing plant remains. Beneath these beds is a series of 60 feet of clear quartz-sandstones, white, yellowish, and red (hematitic) in color. Some of the sandstone is fine-grained and contains thin layers of carbonaceous material. Beneath these clastics occurs a 6-foot layer of limestone below which are 30 feet of reddish calcâreous and angular conglomeratic sandstone. The writers have found lepidodendron and calamite plant remains at several localities in the sandstone beds, and it is hoped that some of these specimens may be identifiable and sufficiently diagnostic to determine whether these sediments belong to the Lower Pennsylvanian or to the Upper Mississippian period.

One of the best Pennsylvanian sections in the Monument area occurs in Whirlpool Canyon (Green River). According to foraminiferal determinations by Lloyd G. Henbest,[5] of the United States Geological Survey, the Morgan formation of this region includes members of Des Moines, Atoka, and Morrow age. The lower limestones rest without apparent disconformity on the carbonaceous shale and sandstone beds described, although there does seem to be some suggestion of erosion locally among the clastics. The lower third of the Morgan formation consists predominantly of cherty limestone layers: The middle part includes fossiliferous marlstone and limestone beds some of which contain varicolored cherts. The upper third of the formation consists of alternating limestone and fine-grained predominantly quartz-sandstone layers, the latter changing in color from red and terra cotta to gray or buff near the top and greatly resembling the overlying Weber sandstone as the contact is approached. Although the Madison is less fossiliferous than the Morgan, it seems possible that both formations might be a source of petroliferous deposits.

The Weber sandstone is a fairly uniform fine- to medium-grained gray to buff friable sandstone, somewhat calcareous, thus susceptible itself to rapid erosion. It is moderately to strongly cross-bedded, in places suggesting wind deposition. Locally, the Weber formation becomes quartzitic. In many places the upper part contains petroliferous outcrops.

Fossils are abundant in many of the formations. One of the most interesting of these groups is the Morrison dinosaurs of Upper Jurassic age. To them must be credited the establishing of Dinosaur National Monument, as it is this colorful series of Morrison flood-plain deposits in which occur the fossils that made the

[5] Personal communication.

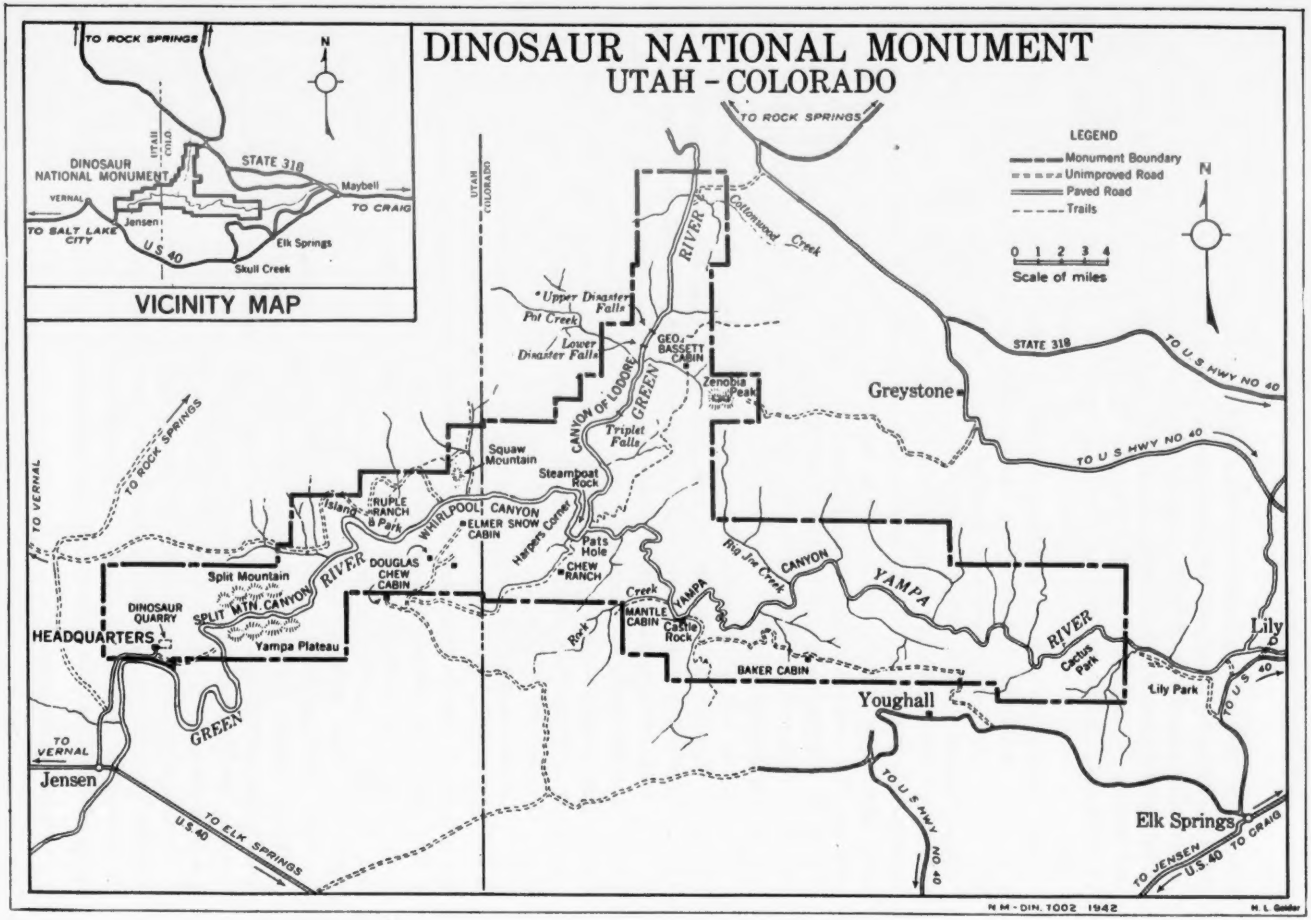


FIG. 1.—Index map of Dinosaur National Monument.

area famous. The dinosaur quarry is outstanding for four reasons: (1) quantity of fossil material, (2) variety, (3) excellent state of preservation, and (4) most nearly complete articulated skeleton, *Camarasaurus lentus* (Marsh). Twenty-three nearly complete and 300 partial skeletons are said to have been excavated from 1909 to 1924, largely by the Carnegie Museum of Pittsburgh, Pennsylvania. Some quarrying was also done by the United States National Museum of Washington, D. C. and the University of Utah during the last 2 years of this period. Of the number of specimens removed, 11 genera and 12 species have been described. They included herbivorous (sauropod and the low-armored *Stegosaurus*), omnivorous (duckbill), and carnivorous (theropod) forms. Crocodiles, turtles, and one aetosaurian form were also found. Small fresh-water unios and gastropods occur, as well as an abundance of silicified wood.

GEOLOGIC HISTORY

The depositional history of the formations in and adjacent to the Dinosaur National Monument is one of great stratigraphic regularity. For the most part, breaks are faunal and lithologic rather than stratigraphic, and a transitional sequence in sedimentation is the rule rather than the exception. Noticeable unconformities are rare. This is particularly true of the the formations representing both Paleozoic and Mesozoic eras. Even the absence of Ordovician, Silurian, and Devonian strata does not reveal a pronounced erosional unconformity. The most conspicuous erosional breaks are between Algonkian (Uinta Mountain group) and Cambrian (Lodore formation), between Mississippian (Madison dolomite) and Pennsylvanian (Morgan formation), and between Moenkopi and Shinarump formations of the Triassic.

Within this area are exposed eighteen major formations (excluding the Browns Park beds, Pliocene) ranging in age from Algonkian (Uinta Mountain group) to Cretaceous (Mancos shale), representing eight geological systems and three eras, and totaling more than 20,000 feet of sediments, all of which were involved in the depositional and diastrophic history of the Uinta Mountains. Ten of these formations are in part of marine origin, indicating the frequency with which the area was submerged beneath the sea.

The major diastrophic and erosional events since the inception of the Uinta Mountains at the close of the Cretaceous are also clearly revealed in the geologic history of Dinosaur National Monument. The total uplift in the central part of the range as a result of folding and faulting may have been as much as 45,000 feet. This figure represents the total thickness of sediments exposed to erosion. Uplift within the Monument area appears to have been 25,000 to 30,000 feet. The geologic history of this section may be summarized as follows. 1. Deposition of shallow marine and continental (lake, flood-plain, and eolian) sediments between Algonkian and Upper Cretaceous time in the more shallow eastern part of the Uinta geosyncline. 2. Folding of this geosyncline during the Laramide revolution elevated the range and formed minor folds along its flanks. This deformation

FIG. 1.—Index map of Dinosaur National Monument.

was accompanied by some faulting. 3. A long period of erosion followed during which the terrain was reduced to a stage of maturity and Mesozoic sediments were exposed. 4. Uplifting and considerable faulting occurred near the close of the Eocene as shown by warping and displacement of some of the Eocene formations of surrounding areas. 5. Then followed another period of erosion during Oligocene and Miocene time, with gradual increasing aridity,[6] resulting in deposition of the Bishop conglomerate or its equivalent (probably Miocene age) and exposing of Algonkian sediments. As erosion continued, trenching of the earlier surface was produced. 6. Some subsidence occurred in the eastern part of the Uinta Range, and the extensive Browns Park formation (Pliocene) was deposited. 7. Continued subsidence and faulting of this area formed a graben in which part of the Browns Park was lowered and protected from erosion. Many of the more prominent faults of the region were formed at this time (late Pliocene or early Pleistocene), with some elevation and tilting toward the west in the eastern end of the range. 8. Development of consequent drainage on the unconformable Browns Park resulted in superposition of the streams and in stream deflection and piracy, as illustrated by Lodore and Split Mountain canyons. 9. With continued general uplift during Pleistocene, entrenching of meanders of the Green and Yampa river systems progressed, establishing the present day stream pattern and forming the deep canyons and other scenic features of Dinosaur National Monument.

[6] Wilmot H. Bradley, "Geomorphology of the North Flank of the Uinta Mountains," *U. S. Geol. Survey Prof. Paper 185-i* (1936), pp. 172–79.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 695-719, 7 FIGS.

STRUCTURAL RELATIONS ON EAST FLANK OF ANADARKO BASIN, CLEVELAND AND McCLAIN COUNTIES, OKLAHOMA[1]

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ABSTRACT

Information obtained from deep oil tests drilled in the past 5 years has disclosed that the Anadarko basin of western Oklahoma is separated from the central Oklahoma platform by a zone of buried large-scale faulting.

The major displacement in Cleveland and McClain counties is a fault zone, herein named the McClain County fault zone, which extends through the two counties from north to south, approximately bisecting them. The total throw of the zone reaches a maximum of more than 2,300 feet. The fault is considered to be a zone of shearing due to differential vertical uplifts between the positive central Oklahoma platform on the east, and the negative Anadarko basin on the west.

Numerous secondary faults are associated with the major fault zone.

Structural differentiation of the two structural provinces was established at least by late Ordovician time, and may possibly date from the pre-Cambrian. However, the major movements were concentrated in two periods of diastrophism in pre-Des Moines Pennsylvanian time.

Structural adjustments were in general continuous into Des Moines and later Pennsylvanian time; however, all faults pass upward into monoclinal folds in the lower part of the Deese group.

INTRODUCTION

Oil discovery and production in Oklahoma during the past several years have recorded a steady expansion of the major oil companies into the deep Anadarko basin of the western half of the state, the last frontier of Oklahoma oil men. Attention has been attracted in particular to the south and east flanks of this great structural basin, and a number of relatively deep discoveries has highlighted the most successful period of wildcatting in Oklahoma for many years.

Because of the paucity of subsurface information the Anadarko basin is still poorly known, but as more deep wells are drilled the complex stratigraphy and structure of the basin are gradually being brought to light. The purpose of this paper is to describe the geologic structure of part of the basin flank in which information is relatively plentiful. The area considered is important in understanding the regional geologic history for it includes parts of three major structural features: the Anadarko basin, Nemaha ridge, and Pauls Valley uplift. Also, the preservation of a nearly complete Pennsylvanian section in a part of the area makes possible a fairly close dating of regional diastrophic movements.

The maps, included as a part of this study, are based entirely on well information. Because of the commercial importance of the area, seismograph information is not available for publication.

STRATIGRAPHY

GENERAL

Except in the Pennsylvanian system the stratigraphy of the area offers few

[1] This paper is the essential part of a thesis submitted to the University of Oklahoma in partial fulfillment of the requirements for the degree of Master of Science. Manuscript received, September 27, 1948.

[2] University of Kentucky. For many courtesies and constructive criticisms, the writer is grateful to Carl A. Moore, who supervised the preparation of the thesis on which this paper is based.

FIG. 1.—Location Map

problems. The pre-Pennsylvanian section is similar to that of southern Oklahoma; the units are widespread and easily recognized, both in sample studies and on electric logs; and, except for divisions of the Simpson group, the terminology is standard and the correlations have been established. However, the Pennsylvanian system comprises a thick sequence of rapidly changing facies in which few units can be identified with certainty for more than short distances. As a result geologists working in the area differ considerably on correlation and nomenclature, particularly of the minor units. Stratigraphic divisions used in this report are in common usage, but correlation of some of the formations with surface formations of the same name has not been established.

SURFACE FORMATIONS

The Hennessey shale crops out over approximately the eastern half of the area; the Duncan sandstone, over the western half. These are of Lower Permian (Leonard) age and consist of continental redbeds.

SUBSURFACE FORMATIONS

PERMO-PENNSYLVANIAN

Lowermost Permian and uppermost Pennsylvanian beds are predominantly non-marine red shales and sandstones, with some gray and green shale and minor amounts of limestone in the lower part. In the area studied the thickness ranges from 3,000 to 4,000 feet.

There is no satisfactory subsurface terminology for this sequence. In the southern part of the area where there is considerable arkose the name Pontotoc is sometimes applied. Most commonly the unit is referred to simply as the "redbeds."

PENNSYLVANIAN

Hoxbar group.—The Hoxbar group is a marine sequence 2,000–3,000 feet in thickness. The top is generally placed at the Pawhuska limestone, but in Garvin County it is considered to be the "Fusulinid limestone," which is approximately correlative with the Pawhuska. The basal formation is the Cleveland sandstone. The Hoxbar is, thus, approximately equivalent to the Missouri series plus the lower two-thirds of the Virgil series of the standard Mid-Continent Pennsylvanian section.

In southern Oklahoma, in the vicinity of the Arbuckle and Wichita mountains, a major unconformity separates the Hoxbar from the overlying Pontotoc formation; but in central Oklahoma this contact is apparently conformable.

There is a notable development of sandstones in the upper part of the Hoxbar group. These include the Hoover sands of the Oklahoma City area, and the several producing sands of the Pauls Valley pool. In the lower Hoxbar the only prominent sandstone is the Layton, which can be recognized in Cleveland County but is not found farther south. All of the sandstones grade into shale and limestone westward into the Anadarko basin.

Several limestones of the Hoxbar are continuous throughout the district. Among the important marker beds, in addition to the Pawhuska, are the Dewey limestone about midway in the Hoxbar, and the Hogshooter and Checkerboard limestones in the lower part. The Checkerboard is a variably developed zone of oölitic limestones; commonly there are two such limestones, termed the "First" and "Second" Checkerboards, separated by 150–300 feet of calcareous shale. Because the Cleveland sandstone which lies directly beneath the "Second" Checkerboard is not everywhere well developed and because there is no evidence of a truncating unconformity, it has become general practice among petroleum geologists to consider the base of the "Second" Checkerboard as the base of the Hoxbar.

Deese group.—The Deese is equivalent to the Des Moines series plus some older conformable beds lost by onlap northward out of the Anadarko basin.

It is primarily a shale sequence in which there is a variable development of sandstone and limestone. In southern McClain and northern Garvin counties the Deese contains several generally recognized sandstones which are known from the top downward as the "First," "Second," "Third," "Fourth," and "Fifth" Deese sandstones. These sands are of great economic importance because, as they progressively wedge out by marine onlap onto the Pauls Valley uplift, they form the multiple stratigraphic trap of the so-called "Golden Trend." Only one such pool is included in the area studied; that is the New Hope pool, Secs. 3, 4, 8, and 9, T. 4 N., R. 2 W., Garvin County, in which production is from the "Fourth" Deese sand.

The Deese sandstones of the Lindsay area are not traceable northward. Sandstones are poorly developed in northern McClain County and Cleveland County and those that do occur are thin, fine-grained, and erratic. Hence, although structural and stratigraphic relations are similar, it is not likely that Deese stratigraphic traps comparable in size with those of the Pauls Valley uplift area will be found around the Oklahoma City uplift.

In Cleveland County there is a well developed limestone, the Oswego, that occurs about the middle of the Deese. This grades southward into shale and fine-grained sandstone, and can not be recognized south of northern McClain County. Above the "Third" Deese sand there is a thin limestone known as the "Gibson zone." It is one of the better marker zones in Garvin County, but it is not generally recognized northward into McClain and Cleveland counties.

A thick detrital zone is at the base of the Deese in western Cleveland and McClain counties, but this is poorly developed or absent in the remainder of the area. The maximum thickness of this zone is 160 feet in a well in Sec. 36, T. 8 N., R. 4 W. The lithologic character is extremely variable, but is marked particularly by dark brown-stained sandstone containing obvious detrital grains, such as shale or limestone fragments. Phosphate nodules, glauconite grains, and variegated shales are common. Although thin conglomeratic zones are present, the sandstones are mostly fine-grained. This detrital zone is the main reservoir bed in

the South and West Moore fields of Cleveland County where it is very porous; but in other wells in which the zone has been encountered, it is firmly cemented and tight.

The thickness of the Deese ranges from more than 1,600 feet in the structurally low part of central McClain County to less than 900 feet on the Oklahoma City uplift in northern Cleveland County and to less than 600 feet on the Pauls Valley uplift in McClain and Garvin counties (Fig. 2). From the central part of the Anadarko basin where it is at least 5,000 feet thick, the Deese thins regionally on the basin flank, both from the base due to marine onlap and, intraformationally, as a result of differential subsidence.

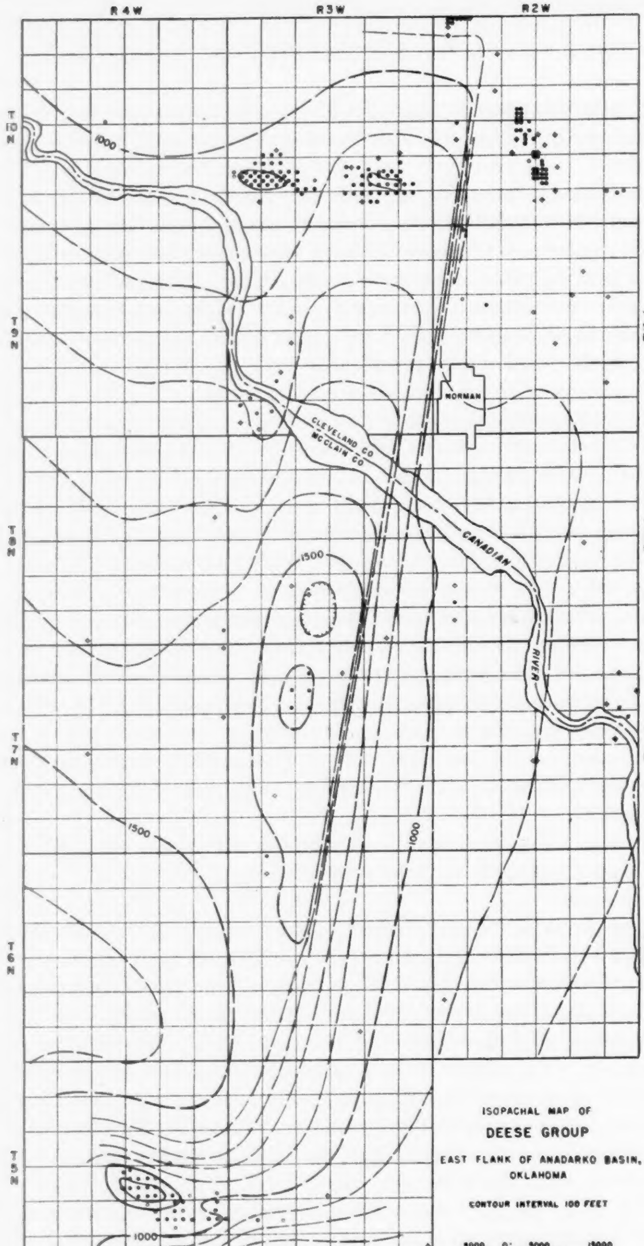
A comparison of the isopachous map of the Deese (Fig. 2) with a structure map (Fig. 3) illustrates the close relation between thickness and structure. The Deese is thickest in the graben of McClain County, the structurally lowest section, and thins onto all the structurally higher areas. There is thinning of the Deese over such secondary features as the anticlines of the Moore pools, the Washington pool, and the Lindsay area, indicating that they were uplifted in part during Deese time. Over these local uplifts the thinning is from 50 to 150 feet, according to the magnitude of the feature.

A major truncating unconformity separates the Deese from underlying strata. The Deese overlies successively all strata from the Dornick Hills group (Lower Pennsylvanian) to the Simpson group (Middle Ordovician) in a pattern that reflects pre-Deese structural movements. The Dornick Hills group was preserved from pre-Deese erosion only in the structurally low western part of McClain and Cleveland counties, and the older beds are progressively truncated both northeastward on the Oklahoma City uplift, and southeastward on the Pauls Valley uplift (Fig. 4).

Deposition of the Deese was in a sea transgressive from the west, and as the Deese is traced eastward from the Anadarko basin, progressively younger beds occur at the base.

In most places the unconformable relationship at the base of the Deese is conspicuous because of the absence of a considerable part of the stratigraphic succession. Where the Dornick Hills is preserved and the amount of section removed by erosion is not known, evidence for the unconformity is not conclusive, and some geologists believe that the Dornick Hills is a part of the Deese group which disappears by onlap. However, an unconformable relationship is strongly suggested by the presence of a typical detrital zone at the base of the Deese, by unconformable thinning of the Deese above the Dornick Hills toward the Oklahoma City uplift, and by the fact that the Dornick Hills is limited to the downthrown side of the major fault of the area.

Dornick Hills "group."—Below the Deese group in the western part of Cleveland and McClain counties is a sequence of black sandy shale and glauconitic brown lithographic to coarsely crystalline limestone. It is found only on the downthrown side of the major fault of the area where it was locally preserved


R4W
R3W
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T 10 N
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T 7 N
T 6 N
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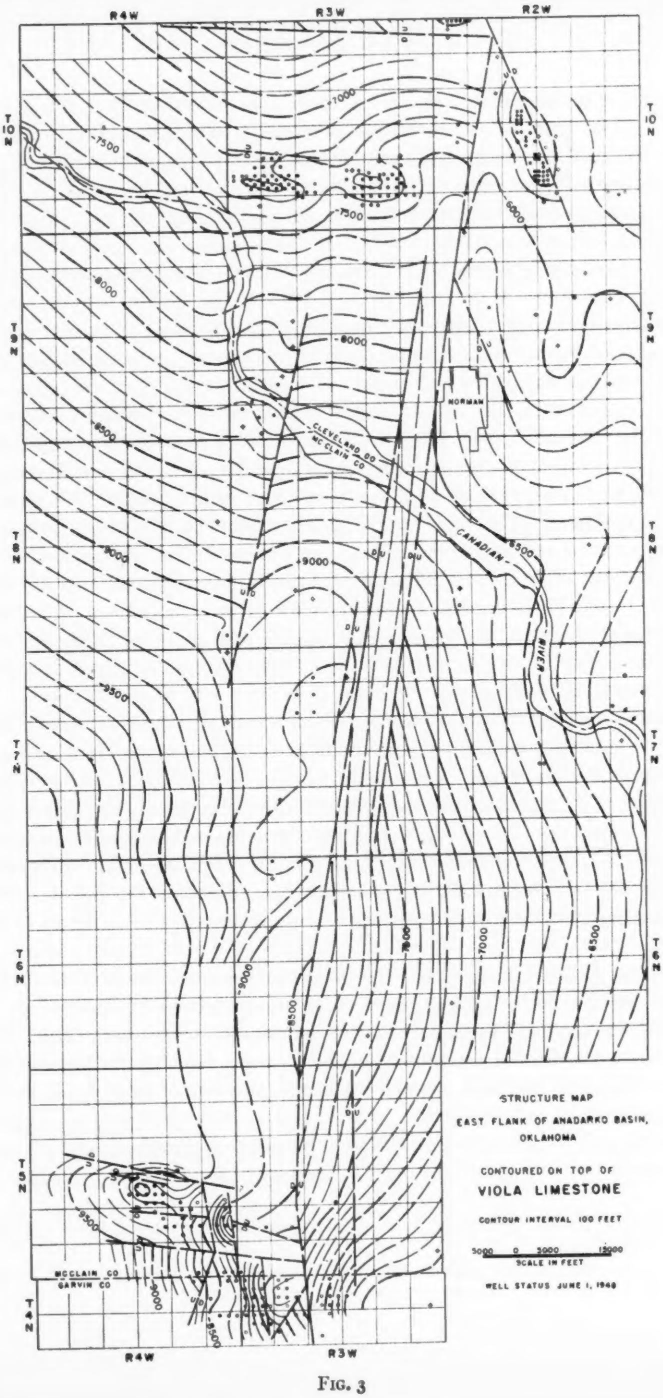
NORMAN
CLEVELAND CO
McCLAIN CO
CANADIAN
RIVER
McCLAIN CO
GARVIN CO
R4W
R3W
ISOPACHAL MAP OF
DEESE GROUP
EAST FLANK OF ANADARKO BASIN,
OKLAHOMA
CONTOUR INTERVAL 100 FEET
5000 0 5000 15000
SCALE IN FEET
WELL STATUS JUNE 1, 1948

FIG. 2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-9500
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6500
7000
7500
NORMAN
CLEVELAND CO
MC CLAIN CO
CANADIAN RIVER
MCCLAIN CO
GARVIN CO
STRUCTURE MAP
EAST FLANK OF ANADARKO BASIN, OKLAHOMA
CONTOURED ON TOP OF
VIOLA LIMESTONE
CONTOUR INTERVAL 100 FEET
5000 0 5000 15000
SCALE IN FEET
WELL STATUS JUNE 1, 1948

FIG. 3

from pre-Deese erosion. It has been identified as far south as T. 6 N., R. 3 W., and as far north as the South Moore pool in T. 10 N., R. 3 W. However, it is missing in the West Moore field and northwestern Cleveland County. The maximum thickness is 300 feet in T. 8 N., R. 3 W.

The Dornick Hills is separated from the underlying beds by a major unconformity, and it is found from central McClain County to northern Cleveland County progressively overlying the Springer shale, Caney shale, and Mayes limestone.

The name Dornick Hills is in common usage for rocks of similar position in the Anadarko basin, and is adopted here to conform to accepted terminology.

Wheeler[3] has suggested the name "Moore formation" for the unit, and has classified it as Atokan in age. He stated it was probably deposited in an embayment of the Atoka sea from the east. This seems an unnecessary complication as both the earlier Springer sea and the later Deese sea advanced over this area from the subsiding Anadarko basin on the west; and to propose, as Wheeler does, a double interchange of positive and negative elements is both unnecessary and contrary to accepted principles of basin tectonics and sedimentation.

Apparently Wheeler was led to his conclusion by the small area in which the "Moore" formation is known. However, no deep wells have been drilled immediately west of the area included in this report; and there is, thus, no reason to assume that the "Moore" is not part of a thicker section of Dornick Hills in the central Anadarko basin.

There is nothing in the occurrence of the Dornick Hills that does not fit the simpler explanation of a normal sea advance from the west, and local preservation in a structurally low area.

Because the Dornick Hills is bounded above and below by unconformities, the precise dating of the regional diastrophic movements is dependent on ascertaining its proper place in the geologic column. However, no paleontologic determination of the age of the Dornick Hills has so far been possible. On physical evidence Wheeler assigned it to the Atokan series, but, as shown, the evidence is not convincing.

Rocks of Morrowan age are present on the northern flank of the Anadarko basin in southwestern Kansas,[4] and from regional considerations they should reasonably be expected to be within the basin and on the eastern flank. Hence, it seems that a provisional assignment of the Dornick Hills to the Morrowan series requires the fewest assumptions and least extrapolation of basic data; and would, therefore, be most acceptable.

The Morrowan is a well defined and universally accepted series, but confusion over terminology of beds younger than Morrow but older than type Des Moines

[3] Robert R. Wheeler, "Anadarko Basin—Geology and Oil Possibilities," *World Oil* (September 29, 1947), p. 156.

[4] M. L. Thompson, "Pennsylvanian Morrowan Rocks and Fusulinids of Kansas," *Univ. Kansas Bull.* 52, Pt. 7 (December, 1944), pp. 409–31.

in the Mid-Continent region is widespread at present, apparently the result of (1) failure to recognize that the pre-Des Moines unconformity is not a time-stratigraphic horizon; and (2) overemphasis on the numerous local unconformities on both flanks of the Oklahoma mountains. If we accept the premise of a pre-Des Moines unconformity decreasing in time value as followed southward into the Anadarko basin, it seems likely that strata equivalent to the Atoka will be found to be represented by the lower part of the Deese group.

Springer shale.—The Springer is a uniform black shale found only in the structurally low part of central McClain County in the vicinity of the Washington pool, and in the Lindsay area of southern McClain County and northern Garvin County. Its thickness is less than 100 feet in central McClain County, and ranges from a feather edge to 450 feet in the Lindsay area.

Although the Springer is truncated by pre-Dornick Hills and pre-Deese erosion, probably a part of the northward thinning from the Lindsay area represents non-deposition. The Oklahoma City uplift was positive during most of early Paleozoic time,[5] and it is likely that the Springer was not deposited much farther north from where it is now found.

MISSISSIPPIAN

Caney shale.—The Caney shale is very similar to the overlying Springer, and the two shales can not be satisfactorily separated on a basis of lithologic character alone. As there is no physical evidence of unconformity between the two shales, it seems likely that sedimentation was essentially continuous from the Mississippian into the Pennsylvanian. The Caney is found only on the Anadarko basin side of the major north-south trending fault which bisects the area, having been removed by pre-Deese erosion on the upthrown block. Average thickness of the Caney is 75 feet.

Mayes limestone.—Below the Caney shale is the Mayes limestone, a dark brown granular and silty limestone, commonly containing a thin glauconitic zone at the base. The Mayes, like the Caney, is present only in the downfaulted part of the area, and where not truncated has a thickness of 75–150 feet.

Woodford shale.—The basal formation of the Mississippian is the Woodford shale, a dark brown extremely hard bituminous shale, ranging from 100 to 200 feet in thickness. It is the youngest pre-Deese formation on the structurally high central Oklahoma area.

SILURO-DEVONIAN

Hunton group.—The Hunton group contains five formations: the upper three, the Frisco, Bois d'Arc, and Haragan, are Devonian in age; the lower two, the Henryhouse and Chimneyhill, are Silurian in age. Over most of the area the upper Hunton has been truncated both by pre-Mississippian and by early Pennsylvanian erosion. As a result the Frisco limestone is ordinarily not present. It has

[5] D. A. McGee and H. D. Jenkins, "West Edmond Oil Field, Central Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 30 (1940), p. 1803.

been tentatively identified in a few wells as a cherty coarsely crystalline limestone.

The Bois d'Arc limestone is in most places the upper formation of the Hunton. However, the Bois d'Arc limestone has been truncated over a relatively large area on the upthrown fault blocks in Cleveland County. It is also missing locally in a small area just north of the Newcastle pool in Sec. 20, T. 9 N., R. 3 W. The Bois d'Arc is composed of 40–65 feet of light-colored, coarsely crystalline limestone and finely crystalline dolomite. The underlying Haragan and Henryhouse are both finely crystalline dolomite and dolomitic limestones. Because of their lithologic similarity they are ordinarily not divided. The lowermost formation, the Chimneyhill, is a medium to coarsely crystalline limestone, and commonly contains a coarsely crystalline pink crinoidal phase.

The greatest thickness of the Hunton group is 520 feet in western McClain County, and it thins eastward on the basin flank. The Hunton is completely truncated on the margins of the Oklahoma City and Pauls Valley uplifts.

ORDOVICIAN

Sylvan shale.—The uppermost Ordovician formation is the Sylvan shale, a gray-green shale with a very characteristic splintery fracture. Its thickness ranges from 180 feet in southwestern McClain County to 100 feet in the eastern and northern part of the area studied. At the base there is commonly developed a somewhat dolomitic zone 20–30 feet in thickness.

Viola limestone.—The Viola limestone consists of two units: an upper, white to gray coarsely crystalline limestone known as the Fernvale; and a lower, finely crystalline dolomitic limestone, usually called the Trenton. The Fernvale limestone has a thickness of about 150 feet in the Lindsay area but thins northward to less than 75 feet in northern Cleveland County. The Trenton limestone, which has a maximum thickness of 350 feet in the Lindsay area, also thins northward to 200 feet.

Simpson group.—The Simpson group has been the objective of nearly all of the deep wells in this area, for herein are the prolific Bromide sands. Only two wells in the area have been drilled through the Simpson into the underlying Arbuckle limestone. Both of these were in the East Lindsay pool of Garvin County, and here the total thickness of the Simpson was approximately 1,300 feet. In subsurface work of this area four formations are recognized; in descending order these are the Bromide, McLish, Oil Creek, and Joins. Each formation has a basal sandstone followed upward by a varying sequence of limestone, dolomite, sandstone, and green shale. At the top of the Bromide is the very characteristic Bromide "Dense" limestone, so-called from its extremely dense, lithographic character. Sandstones are particularly well developed in the Bromide formation, being thick and porous over most of the area except in central McClain County where they have been disappointingly tight.

Arbuckle group.—In the two wells in which it has been encountered, the Arbuckle has been a finely crystalline dolomitic limestone.

Structure

Regional Structure

The area included in this paper lies on the eastern flank of the Anadarko basin, a major structural basin covering all of western Oklahoma north of the Wichita Mountains. At the north the area includes the southern limit of the Nemaha ridge, a major line of buried folding and faulting which extends from central Oklahoma northward into Nebraska. The northern part of the area shows the effect of the Oklahoma City uplift, the greatest of all Nemaha Ridge structures. The southeastern part of the area borders the Pauls Valley uplift which is closely related to the Arbuckle Mountains.

The structure of the surface beds is that of a homoclinal flexure dipping gently westward into the Anadarko basin at a rate of approximately 40–50 feet per mile. The subsurface structure of the Permian and Upper Pennsylvanian beds is very similar to the surface structure except that the dip increases downward as the formations thicken basinward.

Figure 4, a map showing pre-Deese areal geology, graphically shows the underlying structure. Conspicuous are the Oklahoma City uplift on the north and the Pauls Valley uplift on the south. Both were eroded to the Ordovician beds before deposition of the Deese, and around both uplifts the formations appear as concentric bands with the older at the center. Also prominent is the large-scale north-south faulting which separates the structurally high central Oklahoma plateau from the Anadarko basin. The close relation of the Oklahoma City and Pauls Valley uplifts is notable. They are very similar structurally, and both apparently are local highs on the regional positive axis which separates the Anadarko basin on the west from the McAlester basin on the east.

The separation of the two uplifts from the Anadarko basin by the same line of faulting serves to link the geologic history of southern, central, and western Oklahoma.

Faulting

McClain County Fault Zone

This fault zone is herein named for McClain County, Oklahoma, because recent deep drilling in McClain County has determined the location, magnitude, and relation of the fault to the regional structure. The fault extends through the county from north to south as a major zone of linear displacement. This is the key fault of the entire area, and it may be considered as a boundary between two major tectonic provinces, the Anadarko basin on the west and the central Oklahoma platform on the east. This displacement is not a simple fracture, but is a major zone of shearing between the positive element on the east and the negative element on the west.

There are at least two faults in the zone, as determined by the Magnolia's Mayer No. 1 well, Sec. 35, T. 8 N., R. 3 W., which was drilled in the shear zone. Whether there are more than two fractures or whether the faults branch is un-


R4W
R3W
R2W
T 10 N
T 9 N
T 8 N
T 7 N
T 6 N
T 5 N
T 4 N
NORMAN
CLEVELAND CO.
MC CLAIN CO.
CANADIAN
RIVER
MC CLAIN CO.
GARVIN CO.
PRE-DEESE AREAL GEOLOGY
AND
THICKNESS OF
POST-HUNTON PRE-DEESE INTERVAL
LEGEND
DORNICK HILLS
MAYES
SYLVAN
SPRINGER
WOODFORD
VIOLA
CANEY
HUNTON
SIMPSON
5000 0 5000 15000
SCALE IN FEET
WELL STATUS JUNE 1, 1949

FIG. 4

known at this time. On the map they have been drawn as two en echelon faults. This fault zone begins in Sec. 5, T. 10 N., R. 2 W., at the southern end of the Oklahoma City uplift. Here it and an east-west trending fault intersect the Granite Ridge fault which bounds the Oklahoma City uplift on the east. From there it trends about S. 10° W. through Cleveland County, and separates the Moore field in T. 10 N., R. 2 W. from the South and West Moore fields in T. 10 N., R. 3 W. The amount of throw at the extreme northern end is not known; but three miles south, between the Moore and South Moore fields, the displacement of the Viola limestone is 1,400 feet; and the Ordovician formations have been faulted against Lower Pennsylvanian beds. An east-west section (Fig. 5) has been drawn at approximately this point to show relations of the fault. On the downthrown side the Deese overlies the Dornick Hills group; on the upthrown side it overlies the Hunton group. This section indicates differential erosion of the two blocks of approximately 700 feet before Deese deposition. The Deese group thins about 200 feet across the fault, and the remainder of the throw is taken up in higher beds.

There appears to be little flexing or disturbance of the strata near the fault, for two wells, one in Sec. 19, T. 10 N., R. 2 W., and the other in Sec. 6, T. 9 N., R. 2 W., both within ½ mile of the fault, showed a normal sequence and thickness of beds with no indication of high dips or other abnormal conditions. That the base of the Deese is faulted can hardly be questioned, but the faulting disappears in a short distance upward into a monoclinal fold, probably below the Oswego limestone.

As the fault is traced southward, it trends almost at right angles to the strike of the pre-Deese formations; and the throw increases markedly. However, a part of the movement is taken up by a second fault which parallels the first a mile west. The descent into the basin is, thus, by a series of at least two steps. The point of maximum throw is in northeastern McClain County in the southern part of T. 8 N., R. 3 W., where the total throw is nearly 2,300 feet. Of this, approximately 900 feet is represented by the easternmost fault and 1,200 feet by the westernmost fault; the remainder is the amount of dip of the formations between the two faults. The strike of the formations between the two faults is almost at right angles to that on either side.

An east-west section through central McClain County at the point of maximum throw of the fault (Fig. 6) illustrates the fault and the stratigraphic relations of each of the fault blocks. On the structurally lowest block, the Deese is in contact with the Dornick Hills group; on the intermediate block, with the Mayes limestone; on the highest block, with the Hunton limestone. Five miles east of the fault the Woodford shale is beneath the Deese.

The total loss of section beneath the Deese is approximately 800 feet, and the remainder of the throw is dissipated in the Deese and higher formations.

As the faults are traced southward, the strike of the formations gradually swings toward the south, in general paralleling the faults; and a part of the throw

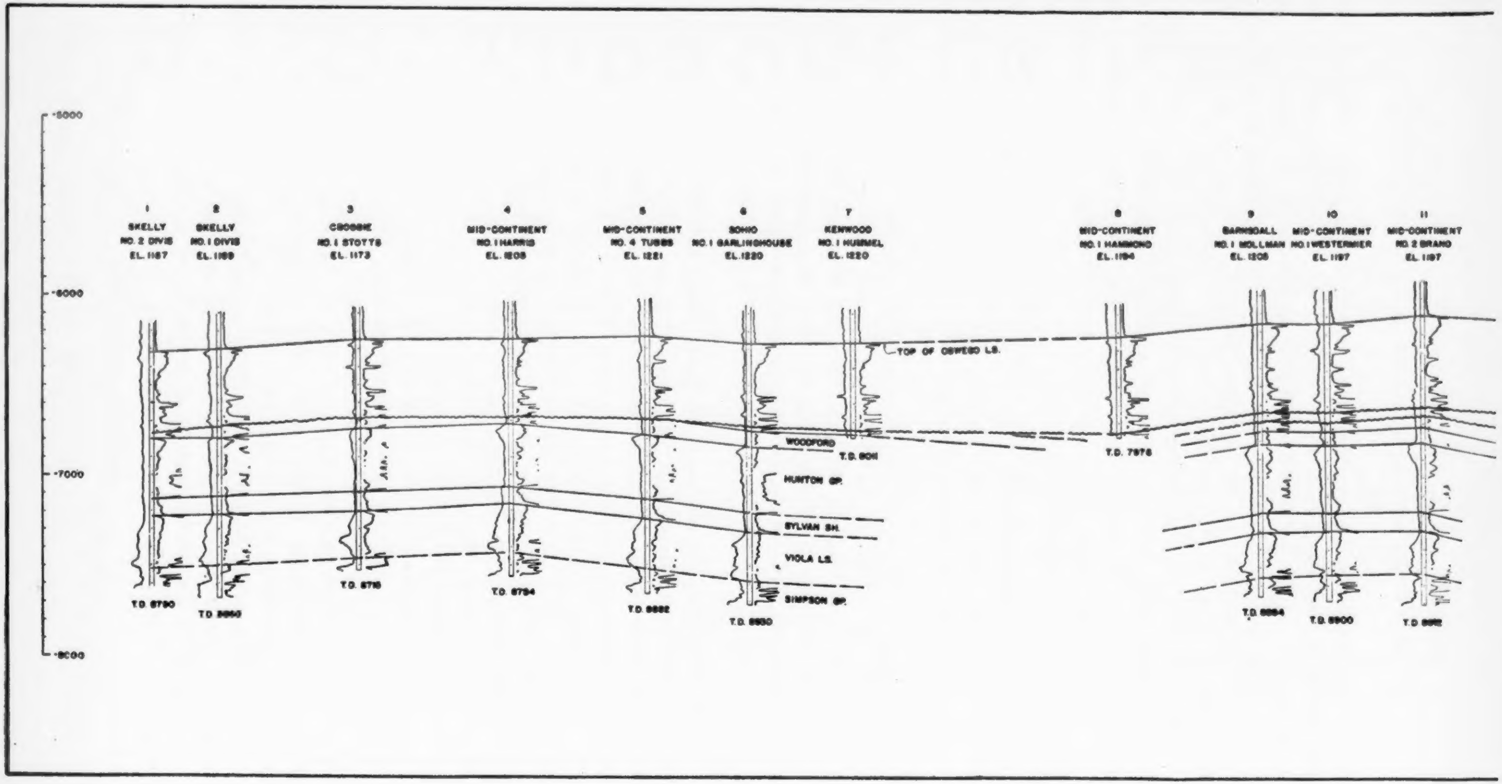

-5000
-6000
-7000
-8000
1 SKELLY NO. 2 DIVIS
2 SKELLY NO. 1 DIVIS
3 CROSBIE NO. 1 STOTTS
4 MID-CONTINENT NO. 1 HARRIS
5 MID-CONTINENT NO. 4 TUBBS
6 SOHIO NO. 1 GARLINGHOUSE
7 KENWOOD NO. 1 HUMMEL
8 MID-CONTINENT NO. 1 HAMMOND
9 BARNSDALL NO. 1 MOLLMAN
10 MID-CONTINENT NO. 1 WESTERMIER
11 MID-CONTINENT NO. 2 BRAND
TOP OF OSWEGO LS.
WOODFORD
HUNTON GP.
SYLVAN SH.
VIOLA LS.
SIMPSON GP.

FIG. 5

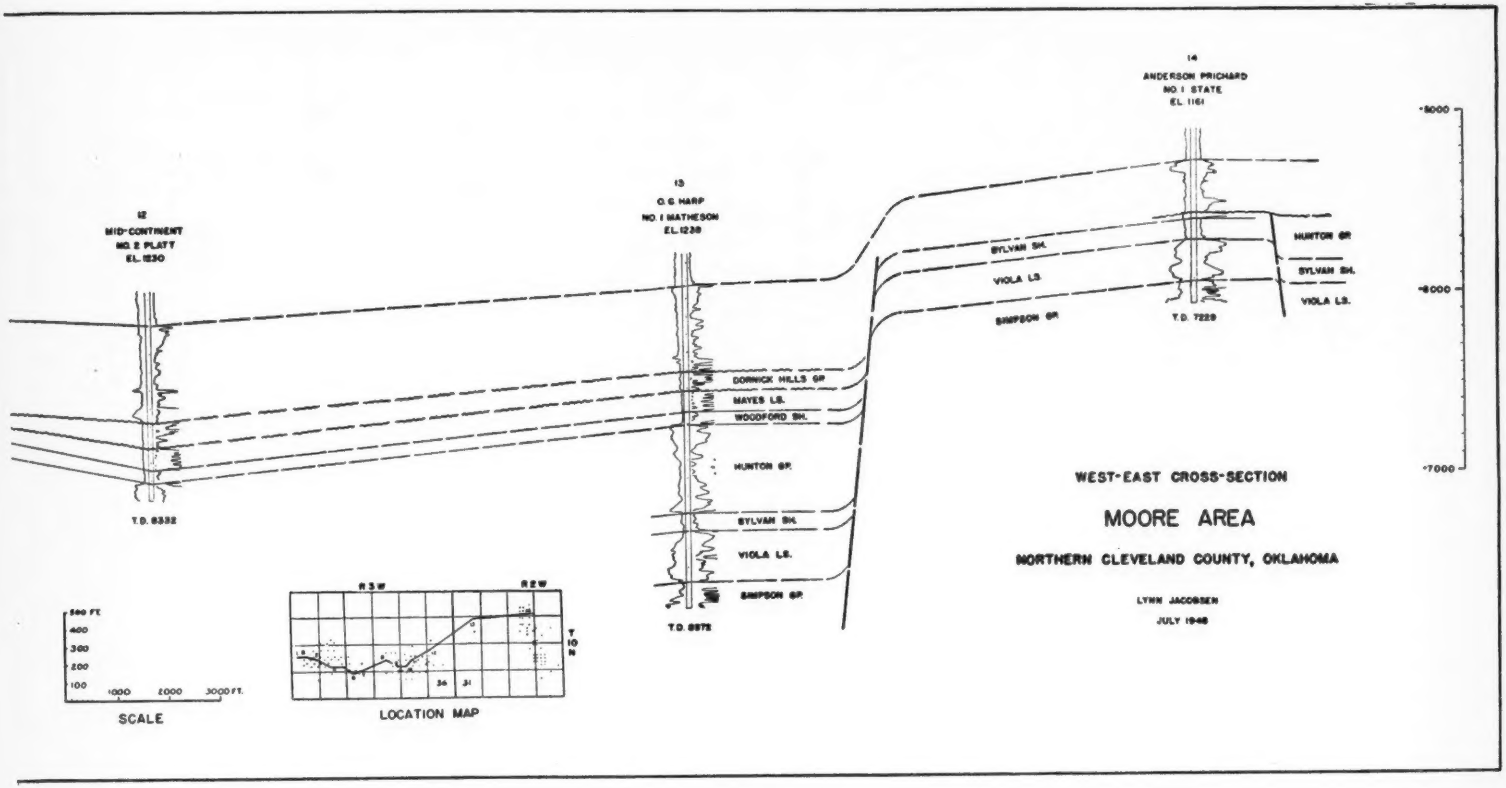


FIG. 5 (*continued*)

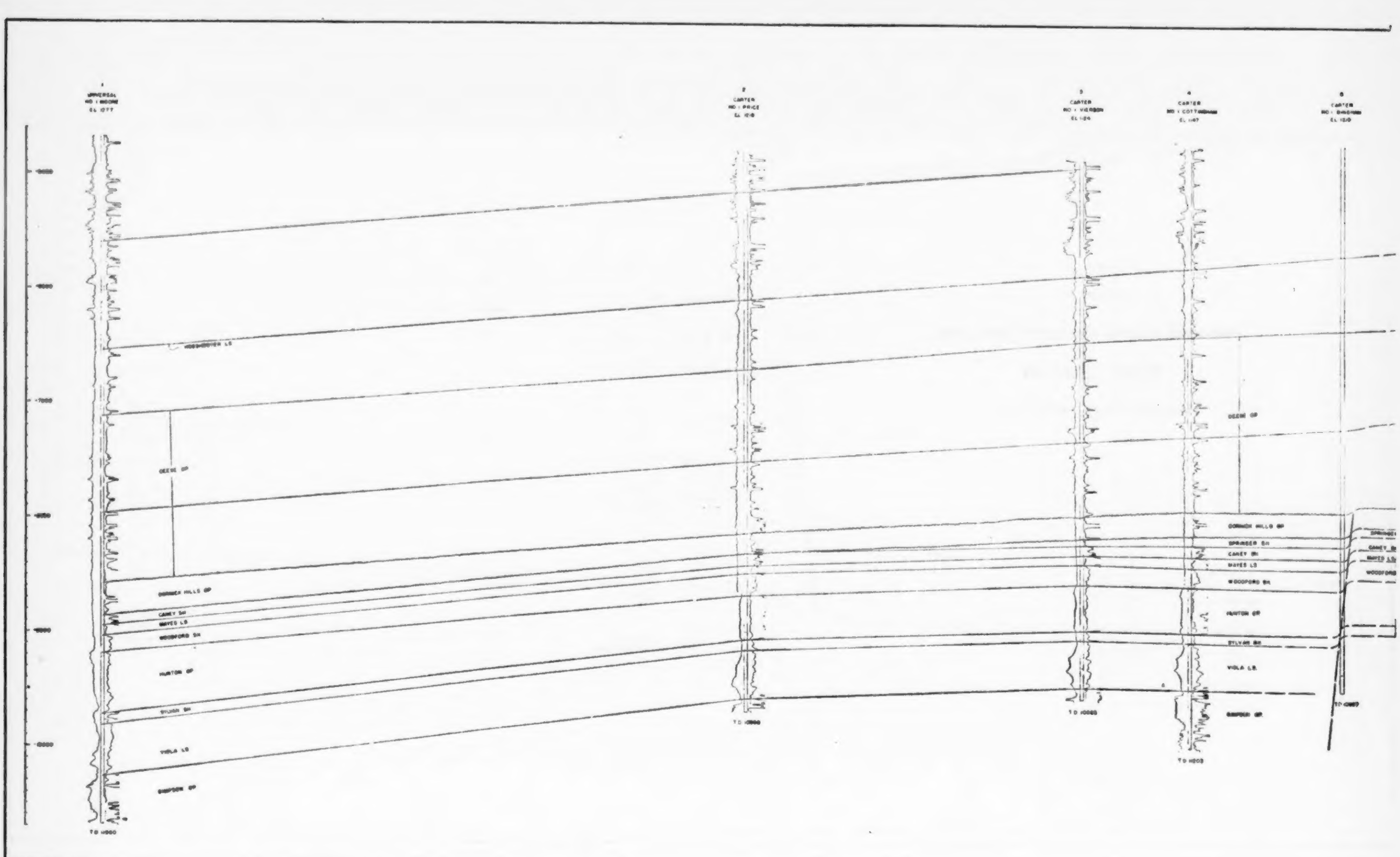

DEESE GP
HUNTON GP
WOODFORD SH
CANEY SH
SPRINGER SH
SYLVAN SH
VIOLA LS
SIMPSON GP

FIG. 6

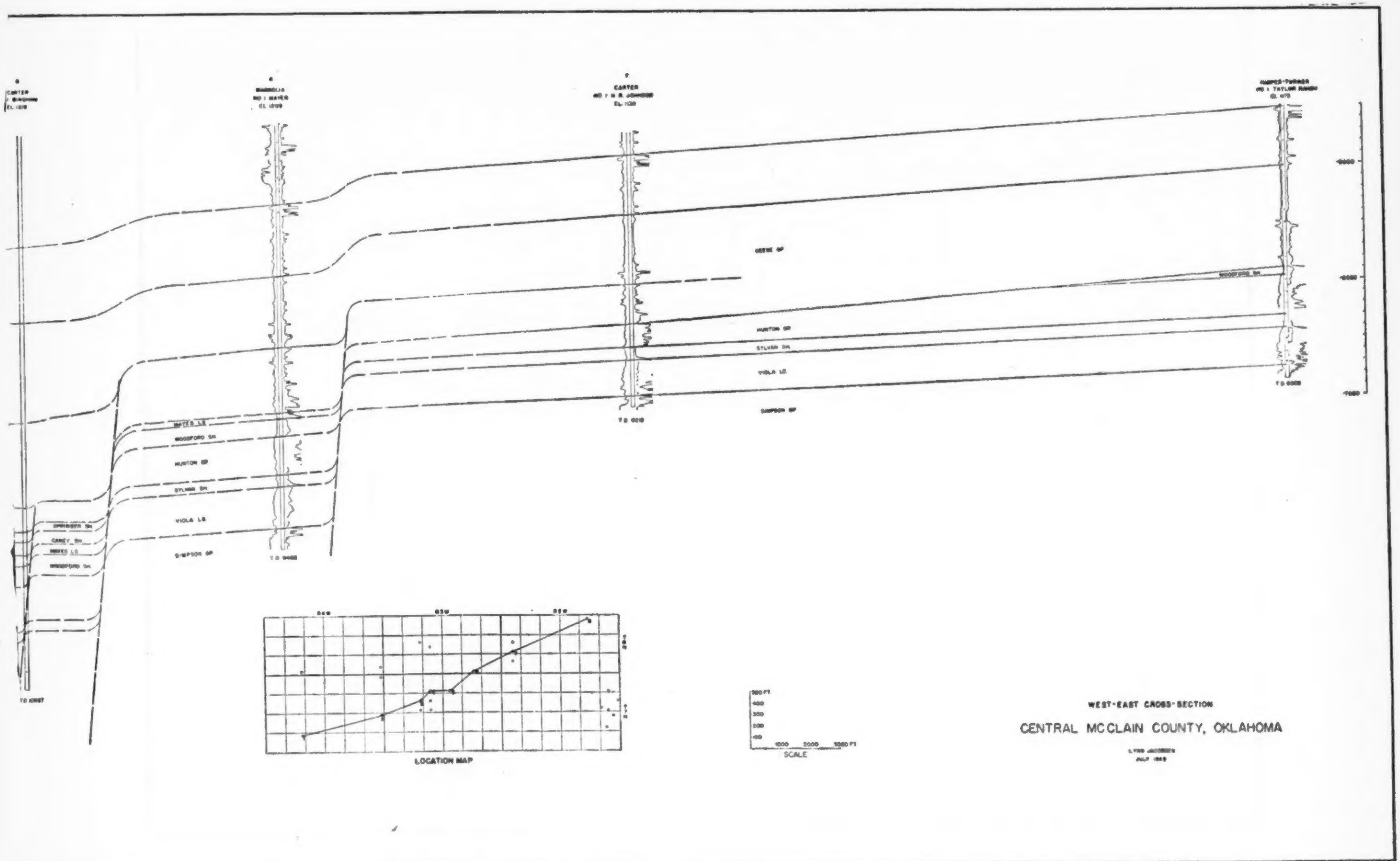
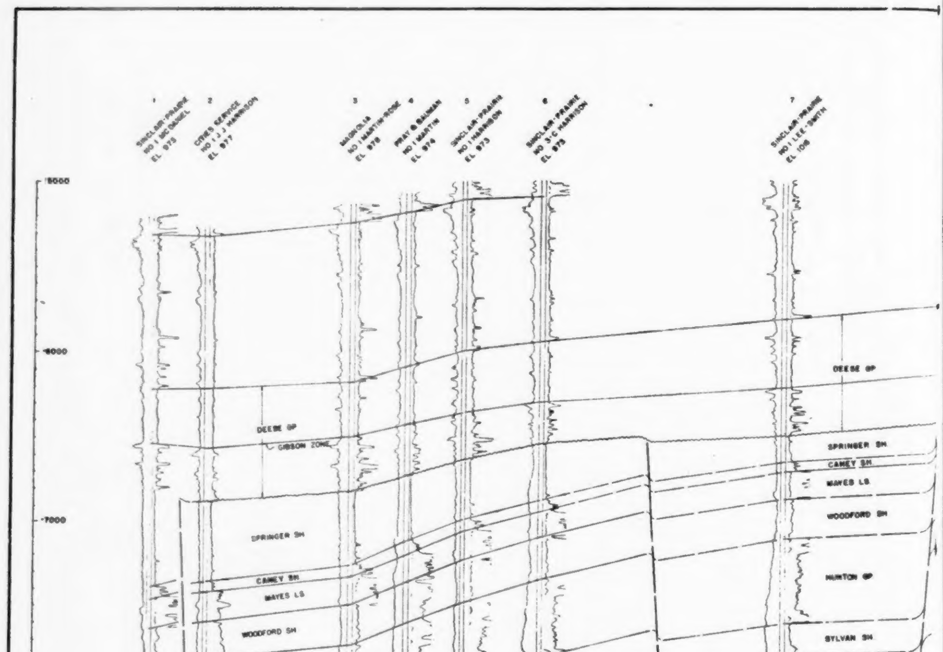


FIG. 6 (*continued*)



1
SINCLAIR-PRAIRIE
EL 973
2
CITIES SERVICE
NO 1 J J HARRISON
EL 977
3
MAGNOLIA
NO 1 MARTIN-ROSE
EL 978
4
NO 1 MARTIN
EL 974
5
SINCLAIR-PRAIRIE
NO 1 HARRISON
EL 973
6
SINCLAIR-PRAIRIE
NO 3-C HARRISON
EL 973
7
SINCLAIR-PRAIRIE
NO 1 LEE-SMITH
-6000
-7000
-8000
-9000
DEESE GP
GIBSON ZONE
SPRINGER SH
CANEY SH
MAYES LS
WOODFORD SH
HUNTON GP
SYLVAN SH
VIOLA LS
SIMPSON GP
T.D. 10124
T.D. 10375
T.D. 10080
T.D. 10776

FIG. 7

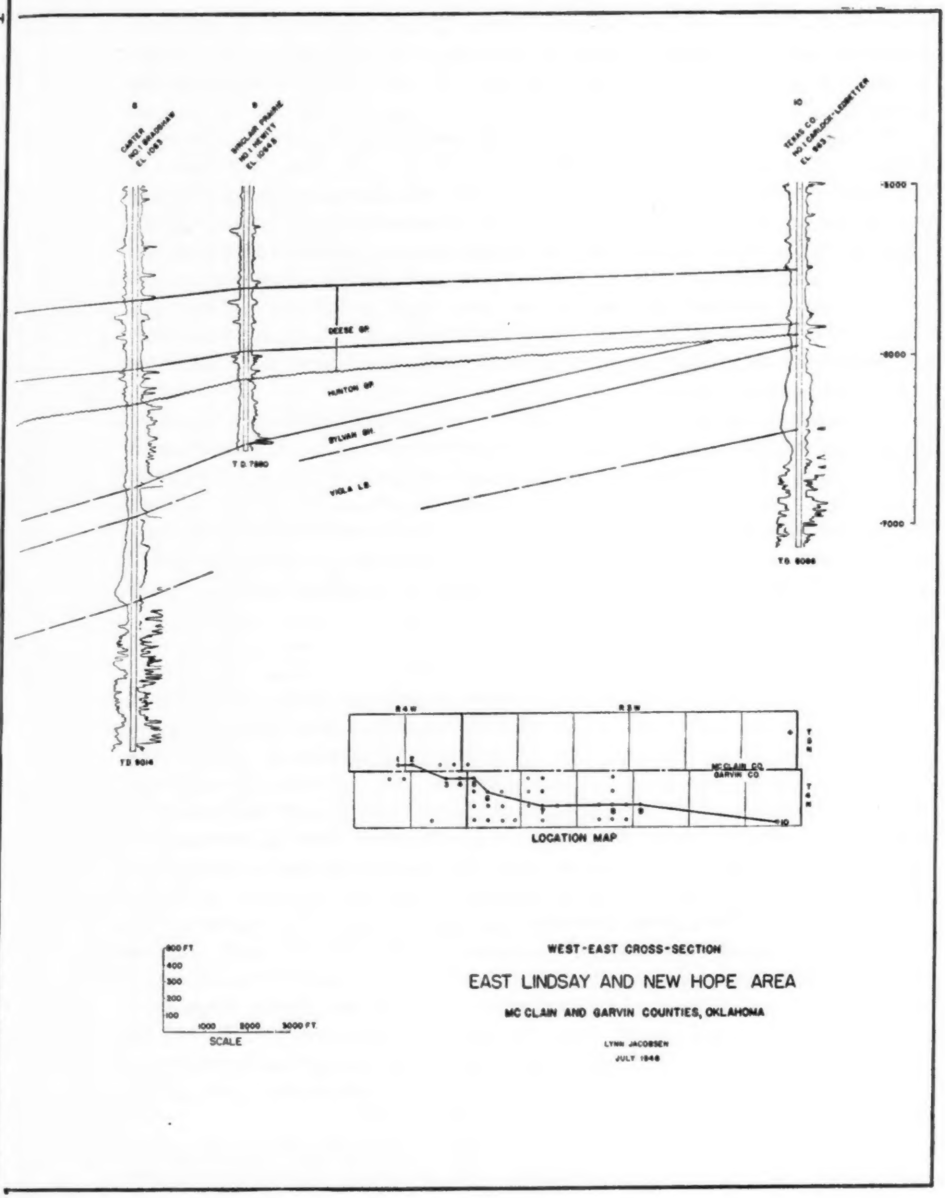


FIG. 7 (*continued*)

is absorbed by the regional homoclinal structure. The easternmost fault seemingly disappears near the southern edge of T. 7 N., R. 3 W., although it may be continuous with a relatively minor fault in T. 5 N., R. 3 W., with which it is directly in line.

The westernmost fault continues, although the throw decreases to a minimum of about 300 feet at the southern edge of T. 6 N., R. 3 W. Near this point the fault trace curves slightly southward, and a few miles farther on curves slightly east of south, there also cutting transversely across the strike. As the fault diverges from the strike of the beds, the throw gradually increases to nearly 600 feet at the south edge of the area. The fault continues southward out of the area for an unknown distance. This and several minor faults are shown in Figure 7, a third east-west cross section at approximately the Garvin-McClain county line. Here the throw of the fault is 500 feet, and the Hunton limestone has been faulted against the Springer shale.

The faults are apparently normal with a very high dip which may even approach the vertical. The courses of the faults are not known in detail, but there is sufficient control to indicate that the traces are exceptionally straight. Furthermore, several deep wells have been drilled within ½ mile of the faults, and none has encountered the main faulted zone. The fault is closely related to the two major uplifts of the area, the Oklahoma City and the Pauls Valley uplifts. It, with several other subsidiary faults, seems to radiate outward from the areas of uplifts.

FAULTING IN LINDSAY AREA

The Lindsay area is the name given to three oil pools on a westward extension of the Pauls Valley uplift at the Garvin-McClain county line. The axis of this structural nose crosses the major line of faulting at approximately right angles. From the point of intersection, cross and branch faults extend in all directions from the major line of faulting, giving a complex mosaic of faulted blocks. The faults are of relatively small displacement; generally the throw is less than 200 feet. The principal exception is an east-west trending fault in Secs. 34, 35, and 36, T. 5 N., R. 4 W., in which the throw is 800 feet. This fault separates the North and Northeast Lindsay pools from the East Lindsay pool. The Springer shale occurs beneath the Deese throughout the area, and the faults are chiefly reflected by a change in thickness of the Springer. Minor faults have had little effect on the thickness of the Deese, and it is doubtful that the base of the Deese is involved in the faulting. However, along the large fault mentioned there is thinning of more than 200 feet in the Deese. Apparently the movements were initiated in post-Springer pre-Deese time; and, except for the large-scale fault, movements were essentially completed before deposition of the Deese.

The minor faults as shown on the structural contour map of the Viola limestone (Fig. 3) are considerably generalized; and are almost certainly a gross oversimplification.

OKLAHOMA CITY FAULT

The major fault that bounds the Oklahoma City uplift on the east extends southeastward into Cleveland County for a distance of approximately 6 miles, and bounds the Moore pool on the east. Opposite the Oklahoma City field this fault has a maximum displacement of 1,500 feet, but its throw decreases southward and is only 300 feet on the northern boundary of Cleveland County. The fault disappears completely in 6 or 7 miles. Its southern limit is ordinarily considered to mark the southern end of the Nemaha ridge line of faulting and folding. In Cleveland County the Hunton limestone is beneath the Deese on both the upthrown and downthrown blocks.

OTHER FAULTS

An east-west trending fault of relatively large displacement is in northern Cleveland County on the downthrown side of the McClain County fault. It apparently joins the McClain County fault and the Oklahoma City fault in Sec. 5, T. 10 N., R. 2 W., and extends westward an unknown distance, probably at least 10 miles. As there is no near-by well control, magnitude and stratigraphic relations of the fault are not well known.

In south-central Cleveland and north-central McClain counties there is a fault paralleling the major McClain County fault about 4 miles west. The upthrown block of this fault is on the west. This fault and the McClain County fault define a graben, which is structurally the lowest part of the area. The throw of the fault is relatively small, being less than 100 feet for most of the length. Southward it passes into a monocline in T. 7 N., R. 4 W. Its northward extent is not definitely known, but it may separate the South Moore field from the structurally higher West Moore field on the west; or, as has been interpreted on the maps, it may pass into a monocline south of the Moore area.

Other relatively minor faults are shown on the structural contour map of the Viola limestone (Fig. 5). Several have been encountered in wells with the resulting omission of a part of the stratigraphic sequence. A well in Sec. 18, T. 9 N., R. 2 W., drilled from the Hunton group into the middle of the Viola limestone; a well in Sec. 20, T. 10 N., R. 3 W., missed nearly all of the Sylvan shale; and a third well in Sec. 3, T. 7 N., R. 3 W., drilled about 100 feet less than normal thickness of the Hunton group. In none of these wells was there any obvious evidence of great disturbance of the beds near the faults.

Probably additional faults will be found, but except for the area on the west and northwest of the Lindsay area in which large-scale faulting can be expected, it is believed that the major features have been delineated.

TIME OF FAULTING

The major diastrophic movements of the area occurred in early Pennsylvanian time, and apparently consisted of two major pulsations: the first in post-Springer pre-Dornick Hills time, and the second in post-Dornick Hills pre-Deese time.

Except for the small area in which the Dornick Hills has been preserved, evidence of the first disturbance has been removed by later erosion. Where the Dornick Hills is now found, the only evident truncation is of the Springer and Caney shales, but presumably older beds were removed higher on the uplifted areas.

It is probable that the large-scale faulting originated partly at this time. This is suggested by the preservation of Springer shale beneath the Dornick Hills group in the graben of north-central McClain County, although on the west the Springer is missing.

The Oklahoma City area was uplifted sharply at this time as shown by the increase of pre-Dornick Hills truncation toward it. Evidence of uplift in other areas has mostly been destroyed, but as part of the faulting was initiated at this time, probably the entire region was affected.

The second great disturbance followed the deposition of the Dornick Hills beds, and was marked by the culmination of the movements begun earlier. Dornick Hills beds are clearly involved in the faulting, and the formations ranging in age from the Dornick Hills group to the Arbuckle group have been truncated on the uplifted fault blocks. Figure 4, a map of pre-Deese areal geology, illustrates the magnitude of the unconformity beneath the Deese. The Dornick Hills group is seen to have been preserved only in the downfaulted block of western McClain and Cleveland counties, while on the upthrown block to the east the Dornick Hills, Springer shale, Caney shale, Mayes limestone, and locally the Woodford shale, have been completely removed. However, except where the Dornick Hills is preserved, this unconformity represents both pre-Deese and pre-Dornick Hills erosion.

This movement marks the major uplift of the Oklahoma City and Pauls Valley areas, for the pre-Deese rocks are truncated in concentric rings around these uplifts, while the Deese and post-Deese formations strike transversely across the strike of the older beds. The faulting separated the Anadarko basin from the central Oklahoma platform and probably marked the beginning of the rapid subsidence of the basin that followed in Deese time.

All the major displacements were clearly initiated before the beginning of Deese deposition, but movements were continuous for a considerable time into later Pennsylvanian time. On the faults of major displacement less than half of the movement took place before deposition of Deese sediments. Although the McClain County fault has a maximum displacement of nearly 2,300 feet, only 900 feet of section was removed from the upthrown block before it was covered by Deese sediments. The remainder of the throw is absorbed in Deese and later beds. The Deese also thins over most of the minor structures, indicating they were uplifted in part during Deese time.

As the thickness of the Deese is affected by the faulting to a much greater extent in the area near the Oklahoma City uplift than farther south, it is likely that movements continued for a longer time in the north.

The most conspicuous result of the faulting was the clear-cut separation of the Anadarko basin from the central Oklahoma positive area. However, the tendency which culminated in the faulting originated much earlier, for at least as early as late Ordovician time the thickness of the sediments reflects a predisposition toward separation of these positive and negative areas. For example, the Viola limestone, which is 500 feet thick in the structurally deep part of McClain County, thins to 200 feet near the Oklahoma City uplift. Between the same areas the Sylvan shale thins from 180 to 100 feet; and the Hunton group, from 520 to 350 feet.

There is not sufficient information to judge whether the lower formations thin regionally, but it seems evident that a regional positive axis was established at least by late Ordovician time. Possibly it may date from the pre-Cambrian.

Slight differential movements were probably continuous from Ordovician on, but near the close of the Devonian period there was a large-scale uplift that presaged the greater movements in early Pennsylvanian time. The movements occurred along the axes which had been established much earlier, and resulted in truncation of the Hunton limestone around the margins of the Anadarko basin. The magnitude of this uplift is obscured over much of central Oklahoma where early Pennsylvanian erosion has removed the Mississippian formations, but it probably represents an early stage of the greater movements which culminated in early Pennsylvanian time.

MECHANICS OF FAULTING

The McClain County fault, the major fault of the area, appears to be a near vertical shear which sharply separates the positive central Oklahoma area from the Anadarko basin on the west. Whatever the ultimate source of the forces which caused the shearing, they were active over relatively broad areas. As pointed out by Bailey Willis,[6] this is a type of movement which commonly separates major positive and negative tectonic elements.

Willis describes these faults as typically extending for many miles, and exhibiting throws of 2,000–3,000 feet. The dip is steep, commonly between 70° and 90°. Parallel faults may dip in the same direction, forming a series of steps; or they may dip in opposite directions, giving a graben or horst.

Although this statement by Willis was intended as a generalized description of a type of faulting, it would serve as a specific description of the faults found in this area.

The forces which cause this type of movement are admittedly unknown because of lack of evidence. Willis[7] suggests for the lifting force a magma bubble beneath the outer crust; or, in the absence of evidence of igneous activity as here,

[6] Bailey Willis, "Normal Fault Structures and Others," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 30 (1946), pp. 1875–87.

[7] Bailey Willis, *op. cit.*, pp. 1876–77.

the increase of volume of crystalline masses as a consequence of adjustments to lowered pressure over a deep-seated molten mass.

One of the important consequences of the vertical displacement of wedge-shaped blocks is the development of compressional forces. The lateral pressure resulting from such displacement is suggested as a logical cause of the minor anticlines in the area.

RELATION OF FAULTS TO OIL ACCUMULATION

In the area studied are part, or all, of sixteen oil fields, eight of which can be considered to be of major importance. Oil is trapped under a variety of conditions, including anticlines, fault traps, porosity traps, and stratigraphic wedge-outs both above and below unconformities. It is a conspicuous feature, however, that nearly all of the pools are associated with faulting; and it is apparent that faulting has been a major feature in localizing the accumulation of oil. The Oklahoma City field, Moore pool, and Washington pool are anticlines faulted on one flank, and the several pools of the Lindsay area are on an anticline which is complexly faulted.

The Lindsay area has been one of the more important and interesting oil field discoveries in Oklahoma during the past several years. The discovery of oil in the area by the Cities Service Oil Company in 1946 has led to an unusually active drilling campaign for deep production. As of June 1, 1948, there were 53 oil wells and 24 drilling wells; and the area had not been defined in any direction except eastward where it is limited by the McClain County fault. Oil is produced primarily from the Bromide formation of the Simpson group, but some production is from the Hunton in the Northeast Lindsay pool. Several wells have tested oil from the lower Simpson sands, but have plugged back to produce from the more prolific Bromide. The depth of production varies from 9,500 feet in East Lindsay to more than 11,000 feet in North Lindsay. Although the area is a large anticline, almost all of the closure is against faults in this anticline; and the oil is apparently trapped in the several fault blocks. Each fault block acts as a distinct reservoir, for the water levels are not continuous and bottom hole pressures ordinarily show abrupt changes at each fault.

On a regional basis the relation of the faulting to oil accumulation is not so clear, for oil is found both on upthrown and downthrown blocks. Also, as in the Moore and South Moore fields, oil is produced from the same formation at a difference in structure of more than 1,500 feet in a distance of 4 miles. The faults may have contributed to the local accumulations by faulting of Ordovician reservoir beds against Pennsylvanian and Mississippian source beds.

CONCLUSIONS

The structural descent from the positive central Oklahoma area to the Anadarko basin is shown to be a zone of large-scale faulting. Considered to separate the two tectonic provinces is a shear zone herein named the McClain County

fault which can be traced from the Oklahoma City uplift on the north at least as far south as the Pauls Valley uplift, a distance of 40 miles. Maximum throw along the fault is more than 2,300 feet.

A tendency toward the development of the distinct negative and positive provinces is considered to have started by Middle Ordovician time, and slight adjusting movements were probably continuous during all of pre-Pennsylvanian time. The faulting was begun some time after the deposition of the Lower Pennsylvanian Springer shale and before the deposition of the Deese group. In this interval there were two major periods of uplift, one preceding and one following the deposition of the Dornick Hills. The post-Dornick Hills pre-Deese interval is the greater.

The post-Springer pre-Deese interval marks the major movements of the Oklahoma City and Pauls Valley uplifts. Movements continued throughout Deese time, and for some time during the later Pennsylvanian.

Faults have controlled the local accumulation of oil by forming traps and possibly by bringing the Ordovician reservoir beds against the Pennsylvanian-Mississippian source beds.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 720-721

GEOLOGICAL NOTES

PIONEERS IN GEOLOGY[1]

FREDERICK A. BURT[2]
College Station, Texas

During the three college years just prior to World War II, and again since the close of hostilities, the writer has conducted a graduate semi-weekly seminar in the History of Geology. No student below the level of fully credited graduate standing in geology (53 geology credit hours in our department) has been admitted to registration. The seminar covers the broad field of geologic science during the two centuries between 1725 and 1925. As part of the work, each participant near the end of the year has submitted, with critical notes, his list of the twenty-five men whom he believed to have contributed most to the advancement of geologic science during these two centuries of its growth. The rating each year was made largely on the following points: (1) discovery and elaboration of new basic principles or methods; (2) impetus given to geologic interest and activity; (3) additions made to the permanent stockpile of geologic fact, data, or procedure.

The writer recently made a review of these papers and combined their ratings into a single list. The names presented show the broad character of the course as they range from that of a man who was strictly a crystallographer to one who devoted his talents almost exclusively to paleobotany. Lists so constructed must necessarily vary widely and this one is not presented with the idea of setting up a geologic "Hall of Fame." The thought is, rather, that an over-all picture of the views of several small groups of serious graduate students with diverse geologic interests who have been studying the history of the broad development of the science might prove interesting.

The twenty-four names appearing most frequently on the lists are: Louis Agassiz, Giovanni Arduino, Élie d'Beaumont, Alexandre Brongniart, Leopold von Buch, Georges Baron Cuvier, James Dwight Dana, George Christian Füchsel, James Hall, Abbe René Just Häuy, James Hutton, Chevalier Jean Baptiste Lamarck, William E. Logan, Charles Lyell, John Michell, Roderick Impey Murchison, Peter Simon Pallas, Franz Posepný, H. Rosenbusch, Horace de Saussure, William Smith, Henry Clifton Sorby, Abraham Gottlob Werner, Israel C. White. The twenty-fifth place is tied between William Morris Davis, John Wesley Powell, John Playfair, and Alcide Dessaline d'Orbigny. In this group the names of Agassiz, Brongniart, Häuy, Hutton, Lamarck, de Saussure, and Smith have appeared on every list so far submitted.

Of these twenty-eight names eight are British, six German, five French, four American, two Swiss, and one each Austrian, Canadian, and Italian. In view of

[1] Manuscript received, March 26, 1949.

[2] Professor of geology, Agricultural and Mechanical College of Texas.

the fact that geology did not begin to develop in America until a century after its beginnings in Europe the percentage of Americans is high. Thirteen of the names are those of English-speaking geologists, and a fourteenth man, making an even fifty per cent of the total, spent a large part of his life and made the greater part of his contributions in England and the United States. When the quarter century beginning in 1925 shall have been added and time has given a perspective to enable us to evaluate the post-1900 period as a part of the whole, it is expected that the place of America will stand in high relief.

The Tulsa Geological Society recently presented the following programs at Tulsa: on April 18, B. W. BEEBE, Anderson-Prichard Oil Company, Oklahoma City, Oklahoma, "Geologic Responsibility in Seismograph Exploration," at the regular program meeting; and on April 15, WILLIAM W. MALLORY, Phillips Petroleum Corporation, Bartlesville, Oklahoma, "Geology of the Velma Pool," and on April 22, CLYDE G. STRACHAN, Gulf Oil Company, "Geology at Spavinaw."

JAMES D. BERWICK is geologist for the United Company of Oregon, Burns, Oregon.

IAN LAURENCE BURR has changed his address from the Shell Company of West Africa to the Sarawak Oilfields, Ltd., Seria, British Borneo, via Singapore.

EARL HARRISON finished requirements for the degree of Master of Science in geology at the University of New Mexico in January and is employed by the Ohio Oil Company as assistant geologist at Durango, Colorado.

CHARLES F. HENDERSON, of Midland, Texas, has resigned from the Stanolind Oil and Gas Company, and is engaged in consulting work at 606 National Bank Building.

L. E. FITTS, JR., has resigned his position with the Sinclair Prairie Oil Company to become chief geologist with the Aurora Gasoline Company, 424 Wright Building, Tulsa, Oklahoma.

SYDNEY H. BALL, geologist and mining engineer, died on April 8, in New York City.

GEORGE S. HUME, head of the Geological Survey of Canada, has been appointed director of the Mines, Forests, and Scientific Services Branch of the Mines and Resources Department of Canada at Ottawa, Ontario.

An International Committee for the Study of Clays was organized in London in August, 1948, at the time of the meeting of the International Geological Congress. S. HENIN of France was elected chairman, and M. LEPINGLE of Belgium secretary. The Committee is limited to not more than two representatives from each country. The members of the Committee from the United States are R. E. GRIM of the Illinois State Geological Survey and W. P. KELLEY of the University of California.

The Shawnee Geological Society has prepared two stratigraphic cross sections of the Pennsylvanian sediments. The main cross section extends south from the Kansas border, T. 29 N, R. 3 E., to the Seminole area, T. 8 N., R. 5 E., Oklahoma. The west-east cross section extends through the latitude of Stillwater, T. 19 N., R. 1 E. to 8 E. The sections are available on two different scales: 1 inch to 1 mile horizontally, and 1 inch to 100 feet vertically; and on a scale half that size. They are printed on good quality paper with permanent blue lines. They are made from electrical logs supplemented with sample studies and show unconformities and facies changes. They are available in either size print for $10 per set by writing the secretary of the Shawnee Geological Society, Box 169, Shawnee, Oklahoma.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 722-726

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library, and are available, for loan, to members and associates.

EOCENE STRATIGRAPHY AND FORAMINIFERA OF THE AQUIA FORMATION, BY ELAINE SHIFFLETT

REVIEW BY JOHN R. SANDIDGE[1]
San Antonio, Texas

"Eocene Stratigraphy and Foraminifera of the Aquia Formation," by Elaine Shifflett. Published by the State of Maryland, Board of Natural Resources, Department of Geology, Mines, and Water Resources, Joseph T. Singewald, Jr., Baltimore, Maryland, director, as *Bulletin 3* (1948). 6×9 inches, 93 pp., 21 figs., 5 pls.

Publication of this paper records another achievement for micropaleontology. Miss Shifflett has gone into a classical area of early geological, stratigraphic, and paleontological investigation in North America, and by application of current subsurface methods she has revealed stratigraphic conditions beyond the scope of the pioneer workers. This study demonstrates again the value of foraminifera for purposes of accurate correlation locally and regionally, as well as the fact that they provide a source of information in well samples which reveals much geological history previously passed over.

This report reviews earlier works on the Eocene of Maryland briefly but adequately, and coordinates the new work with them. Correlation of the surface expression of the Aquia formation in Maryland with neighboring sections across the Potomac in Virginia is well handled despite inherent vagaries in these sediments. They are glauconitic quartz sands with varying amounts of calcareous clay and mica. Regionally the Aquia is shown to be equivalent to the lower Wilcox of the Gulf Coast, particularly as represented in the Salt Mountain limestone, Tuscahoma sand, Bashi and Hatchetigbee formations. Crossing the Atlantic these formations are correlated with the Ypresian and part of the Cuisian of Europe.

The most significant results from a practical standpoint are given in the history of the Maryland Eocene. Well records demonstrate that on the Eastern Shore only Jackson (upper Eocene) occurs,[2] resting on Midway (Paleocene), while on most of the Western Shore Jackson sediments are absent and the Aquia rests directly on Cretaceous. An isopach map of the Aquia indicates it was deposited in a narrow basin or trough bounded on the southeast by an area of non-deposition in Wilcox time. The Jackson sea in turn appears to have invaded only the southeastern edge of this basin, overlapping Wilcox-Claiborne sediments in a sharp wedge. Paleocene extends westward to a line approximately bisecting the Maryland Peninsula. Three cross sections and five maps demonstrate these relationships.

Systematic descriptions of foraminifera occurring in the Aquia are presented and illustrated on five gelatin plates. The figures are retouched photographs. One check list of foraminifera from outcrops, and eight lists from well samples have been tabulated. Although a third of the approximately seventy-five species have been treated by Joseph A. Cushman in his 1944 faunal study of the Aquia in Virginia, it is a convenience to have the

[1] Geologist and paleontologist, Magnolia Petroleum Company. Review received, March 12, 1949.

[2] See also: "Tertiary and Cretaceous Subsurface Geology of the Eastern Shore," *Maryland Dept. Geology, Mines, and Water Resources Bull. 2* (1948).

large assemblage of foraminifera from the Aquia of Maryland brought together in this paper. Miss Shifflett describes one new variety and six new species.

The publication well merits consideration by Tertiary stratigraphers and paleontologists who are engaged in economic work for two reasons: (1) it presents some interesting stratigraphic methods, and (2) it contains a sizeable foraminiferal fauna of Wilcox age.

GEOTECTONIC RESEARCHES, BY H. STILLE AND F. LOTZE

REVIEW BY W. A. VER WIEBE[1]
Wichita, Kansas

Geotektonische Forschungen, edited by H. Stille and F. Lotze. Heft 6. "Zur Geologie der Iberischen Meseta" (Geology of the Iberian Plateau). Articles by F. Lotze, W. Carle, and P. Schmidt-Thomè. 92 pp., illus. Published by Gebrüder Borntraeger, Berlin-Zehlendorf (1945). In German.

Southern Europe experienced extensive and complicated orogeny during the closing epochs of the Paleozoic era. Great chains of mountains were built from Ireland, through southern England into southern France as well as elsewhere. One branch of these mountains trends nearly north and south through Spain. The chains of mountains and the orogenic epochs have been variously named the Paleozoic Alps, the Hercynian orogeny, and the Variscan orogenies. The last name is used by Lotze in the introduction to this part of his researches. Pamphlet No. 6, edited jointly by Lotze and Stille, attempts to show that the folding in the Iberian Plateau probably took place during late Paleozoic time and that it is the Asturian phase of the Variscan orogeny.

The western half of Spain and the eastern half of Portugal form a convenient cartographic unit and have been called the Iberian Plateau by the authors. It is bounded on the north by the Bay of Biscay, on the south by the Guadalquivir River, on the east by a lobate zone trending north and south through a point west of Madrid, and on the west by a nearly straight line through a point east of Lisbon. This block of the earth's crust evidently was a positive area throughout most of Paleozoic time.

Separate articles by Walter Carlé and by P. Schmidt-Thomè bring out details of stratigraphy and structure which seem to substantiate the conclusion that practically all the folding which now can be seen in the Iberian Plateau must be assigned to one of the phases of the Variscan orogeny.

For various reasons geological work in this part of Europe is difficult. Lack of maps and lack of roads make traverses uncertain. Great intrusions of igneous rocks which accompanied the orogenic movements have metamorphosed the sediments. Finally, the orogenic disturbances were violent, producing fragmentation, as well as much folding and faulting. Those who are interested in unravelling the secrets of the earth's crust are therefore grateful to the various authors of this pamphlet for the light they have thrown on this part of the European continent.

RECENT PUBLICATIONS

AFRICA

La Carte Geologique Internationale de L'Afrique au 1:5,000,000. Being prepared in 9 sheets. Sheets I, II, III, and IV of northwest, north, and northeast Africa may be purchased from the Bureau d'Études Géologiques et Minières Coloniales, 12 rue de Bourgogne, Paris VII, France. Price of each sheet, 500 fr.

[1] Professor of geology, University of Wichita. Review received April 15, 1949.

ALABAMA

* "Eocene and Oligocene Foraminifera from Little Stave Creek, Clarke County, Alabama," by Orville L. Bandy. *Bulletins of Amer. Paleontology*, Vol. 32, No. 131 (March 4, 1949). 211 pp., 2 figs., 1 table, 27 pls. Paleontological Research Institution, Ithaca, New York.

ALASKA

"Geology of the Iniskin Peninsula," by C. E. Kirschner and D. L. Minard. *U. S. Geol. Survey Prelim. Map 95*, Oil and Gas Inves. Ser. (April 1, 1949). Sheet 39×53 inches. Scale: 1 inch equals 4,000 feet.

ALBERTA

* "Leduc Oil Field, Alberta, Canada," by Theo. A. Link. *Bull. Geol. Soc. America*, Vol. 60, No. 3 (New York, March, 1949), pp. 381–402; 16 figs., 3 pls.

BRAZIL

* "Relatório de 1947," *Conselho Nacional do Petrôleo* (Rio de Janeiro, 1948). 216 pp., 27 figs. Report on petroleum industry. Includes geology and petroleum possibilities in states of Para, Maranhao, Piaui, Sergipe, Bahia, Parana. In Portuguese.

CALIFORNIA

* "Tejon Oil Field," by Fred E. Kasline. *California Oil Fields*, Vol. 34, No. 1 (San Francisco, January-June, 1948), pp. 3–12; 5 pls., 3 tables.

CUBA

Paleontologia Cubana, Tomo 1 (July, 1949, circa). "Los Equinodermos Fósiles de Cuba," by Mario Sanches Roig; and "Significación Estratigráfica de los Equinodermos Fósiles Cubanos," by Jorge Brodermann. May be purchased by writing Dortores Mario Sanchez Roig and Jorge Brodermann, Cerro No. 1962, Habana, Cuba. Price, $5.00, postpaid.

ENGLAND

* "Wealden Petrology: the Top Ashdown Pebble Bed and the Top Ashdown Sandstone," by Percival Allen. *Quar. Jour. Geol. Soc. London*, Vol. 104, Pt. 2, No. 414 (London, January, 1949), pp. 257–321; 23 figs., 12 tables, 1 pl. (photomicrographs of 27 mineral grains). For sale by Longmans, Green and Company, Ltd., 6–7 Clifford Street, London, W. 1. Price, this issue, 10 shillings.

* "Permo-Triassic Geology of South Cumberland and Furness," by K. C. Dunham and W. C. C. Rose. *Proc. Geologists' Assoc.*, Vol. 60, Pt. 1 (London, March 25, 1949), pp. 11–40; 6 figs. For sale by Benham and Company, Limited, High Street, Colchester. Price, this issue, 5 shillings.

GENERAL

* "Aerial Mapping for Oil," by G. P. Mott. *World Petroleum*, Vol. 20, No. 3 (New York, March, 1949), pp. 66–70; 8 figs.

*"Symposium on Fuel Reserves in the United States," introduction by George Armistead, Jr. *Oil and Gas Jour.*, Vol. 47, No. 46 (Tulsa, March 17, 1949), p. 111. "Petroleum," by Wallace E. Pratt, pp. 112–17. "Natural Gas," by George G. Oberfell, pp. 118–37. "Solid Fuels," by Arno C. Fieldner, pp. 138–45; 2 figs. "The National Interest in Maintaining Adequate Reserves," by Joseph C. O'Mahoney, p. 146.

Introduction to College Geology, by Chauncey D. Holmes. Scheduled for publication in May. Macmillan Company, 60 Fifth Avenue, New York. Price, $4.25 (probable).

Principles of Structural Geology, by C. M. Nevin. 4th ed. (1949). 410 pp. Scheduled for

publication in June. John Wiley and Sons, Inc., 440 Fifth Avenue, New York. Price, $5.00 (probable).

Introduction to Physical Geology, by William J. Miller. 5th ed. (1949). 482 pp. Cloth. Illus. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. Price, $4.50.

Textbook of Geomorphology, by P. G. Worcester. 2d ed. (1949). 584 pp. Cloth. Illus. 6×9.25 inches. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. Price, $5.25.

* "The Origin of Red Beds," by Paul D. Krynine. *Tran. New York Acad. Sci.*, Ser. II, Vol. II, No. 3 (79th Street and Central Park West, New York 24, N. Y.), pp. 60–68; 10 figs.

* *Ur- und Neuozeane* (Old and New Oceans), by Hans Stille. 68 pp., 2 maps in color, 4 text figs. 8.25×11.75 inches. Paper cover. Published in 1948 by Akad.-Verlag G.m.b.H., Schiftbauerdamm 19, Berlin NW. 17. *Abhandl. Deutsch Akad. Wissenschaften Berlin*, Jahrgang 1945/46, Nr. 6. In German. Price, 7DM.

* Rinehart's Production Statistics, Texas, 1948, compiled and edited by the staff of Ira Rinehart's Central Information Office. 349 pp. 8.5×11 inches. Plastic binding. A companion volume to Rinehart's *1949 Yearbook*. Detailed tabulations of oil, gas, and condensate production for each producing field in Texas in 1948. Published by Rinehart Oil News Company, Dallas, Texas. Price, $10.00.

ILLINOIS

Oil and Gas Map of Illinois. 30×51 inches. Scale, 1 inch equals 8 miles. 4 colors. One copy free to residents of Illinois and to public libraries for 4¢ postage (folded) or 15¢ (rolled) until June 1, 1949. State Geological Survey, Urbana, Illinois. Price, $0.35.

IOWA

* "Devonian-Mississippian Formations of Southeast Iowa," by Leo A. Thomas. *Bull. Geol. Soc. America*, Vol. 60, No. 3 (New York, March, 1949), pp. 403–38; 4 pls.

JAPAN

* *Handbook of the Japanese Societies of Natural Science and Cultural Science*, Vol. 1 (1949). 45 pp., 10×14.25 inches. Mimeographed. Scientific Data Section, Scientific Education Bureau, Ministry of Education, Kasumigaseki, Chiyoda-ku, Tokyo, Japan.

MICHIGAN

* "Deep River Field, Michigan, Unique Example of Persistent Exploration," by Raymond S. Hunt. *Independent Monthly*, Vol. 19, No. 12 (Tulsa, Oklahoma, April, 1949), pp. 15, 17, 42, 44, 47; 3 figs.

NEW MEXICO-COLORADO

* "Structures of the San Juan Basin," by Frank C. Barnes. *Oil and Gas Jour.*, Vol. 47, No. 48 (Tulsa, March 31, 1949), pp. 97–100; 1 map, 3 tables.

OKLAHOMA

* "West Red River Field, Oklahoma," by H. B. Hill, Kenneth H. Johnston, T. L. Coleman, and J. M. Seward. *Oil and Gas Jour.*, Vol. 47, No. 49 (Tulsa, April 7, 1949), pp. 70–77, and 94; 4 figs. Condensation of *U. S. Bur. Mines Rept. Inves. 4450*

* "Geological Resources of the Trinity River Tributary Area in Oklahoma and Texas," edited by A. E. Weissenborn and H. B. Stenzel. Prepared by the U. S. Geol. Survey and the Univ. of Texas Bur. Econ. Geol. *Univ. Texas Bur. Econ. Geol. Pub. 4824* (Austin, December 15, 1948), 252 pp., frontispiece, 33 figs. 7.75×10 inches. Paper cover.

PERU AND BOLIVIA

* "Geology of the Lake Titicaca Region, Peru and Bolivia," by Norman D. Newell. *Geol. Soc. America Mem. 36* (New York, March 28, 1949). 111 pp., 21 pls., 14 figs. Coth. 6.5×10 inches, over-all.

ASSOCIATION DIVISION OF PALEONTOLOGY AND MINERALOGY

* *Journal of Paleontology* (Tulsa, Oklahoma), Vol. 23, No. 2 (March, 1949).
"Louisiana Cane River Eocene Foraminifera," by Keith M. Hussey.
"The Age of the *Hannatoma* Mollusk Fauna of South America, a Symposium"
- "Age of the Carbonera Formation near Cúcuta, Colombia," by J. Wyatt Durham.
- "The *Hannatoma* Fauna in Colombia and Venezuela," by Arthur N. Dusenbury, Jr.
- "The *Hannatoma* Fauna in Colombia and Venezuela," by Hollis D. Hedberg.
- "Note on the Stratigraphic Position of the *Hannatoma* Zone in the Western Táchira Region, Venezuela," by L. Kehrer.
- "Age of the *Hannatoma* Fauna," by Jay Glenn Marks.
- "The *Hannatoma* Fauna in the Zapotal Sands of Southwest Ecuador," by R. M. Stainforth.
- "Age of the Chira Group, Northwestern Peru," by Benton Stone.

"Additional Conodonts from the Pennsylvanian of Iowa," by Walter Youngquist and R. H. Downs.
"Early Tertiary Ostracoda from the Western Interior United States," by Frederick M. Swain.
"The Permian Fusulinids of Timor," by M. L. Thompson.
"Tertiary Coralline Algae from the Dutch East Indies," by J. Harlan Johnson and Bernard J. Ferris.
"The Maquoketa Coquina of Cephalopods," by A. K. Miller and Walter Youngquist.
"A New Type of the Fusulinid Foraminifera from Central Japan," by Shoshiro Hanzawa.
"A New Miocene *Lepidocyclina* from Shizuoka Prefecture, Japan," by Masao Morishima.
'Five New Varieties of Graptolites from Tennessee and Virginia," by Charles E. Decker.

PALEOZOIC CROSS SECTION FROM SOUTH-CENTRAL TENNESSEE TO CENTRAL MISSISSIPPI

The Mississippi Geological Society has announced the release of a geologic cross section showing Paleozoic formations from south-central Tennessee to central Mississippi. The section shows approximately 16,400 feet of rocks ranging from pre-Cambrian granite to late Pennsylvanian shale, as shown by 12 deep oil test wells.

The cross section was prepared by the Paleozoic committee of the Mississippi Geological Society as a cooperative undertaking of regional geologic studies under the auspices of the Geologic Names and Correlations committee of the A.A.P.G. It is approximately a fifth part of a master section extending from southern Ontario, across Michigan, Indiana, Illinois, Kentucky, Tennessee, Alabama, and Mississippi. The full composite section, not yet released, shows three major basin areas, and four major anticlinal areas or arches. These sections were on display at the annual convention of the Association in March. The Michigan basin and the Illinois basin are both commercial oil and gas provinces, but the Black Warrior basin of Alabama and Mississippi has not been proved to have important oil and gas reserves.

The horizontal scale is 1:500,000, and the vertical scale is 1 inch equals 300 feet. A descriptive text is carried on the side of the chart, which measures 42 by 60 inches. Prints are available from Charles E. Buck, treasurer, Mississippi Geological Society, Box 2253, Jackson, Mississippi, for $2.25 postpaid, or at the Skelly Oil Company Office, for $2.00.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 727-771, 25 FIGS.

ASSOCIATION ROUND TABLE

AMERICAN GEOLOGICAL INSTITUTE[1]

A. I. LEVORSEN[2]
Stanford University, California

The American Geological Institute has finally arrived! Its birthday was November 15, 1948, when directors from eleven national member organizations met at the Academy of Sciences in Washington for its first annual meeting. The period of gestation extends back to the memorable address, "Geological 'Union Now'," by Carey Croneis at the Fort Worth convention of this Association in April, 1943. It was immediately followed by the first of a total of five exploratory meetings which were held through the intervening years and which were attended by representatives of many or all of the national geological and geophysical organizations.

Grave doubts of the survival of the Institute idea were often held and countless hours of sincere effort by many persons were put into developing ways and means of achieving a united front for geology in America. As a matter of fact, our problems are in a small way parallel with those of the United Nations—many organizations of differing backgrounds, financial abilities, customs, sizes, and characteristics, all trying to unite on those problems of common interest for their own betterment. That we have reached an agreement on the purposes, and the methods by which we hope to achieve these purposes, is, I believe, a tribute to our good common sense.

The purpose of the American Geological Institute, as stated in its Articles of Organization, is "the advancement of geology and its application to human welfare by providing a means for the cooperation of organizations active in the fields of pure and applied geology."

Three words symbolize the objective. They are: *cooperation*, *coordination*, and *service*. Membership in the Institute is open to all those organizations concerned with the earth sciences—geology, geophysics, geochemistry, and mineral engineering. The Institute is organized to provide a channel for *cooperation* among them; to provide a means of *coordination* of their activities; and to *serve* in furthering their joint aims. The scope of its operations will be the advancement of the earth sciences as a whole, which can best be accomplished by joint action.

Eleven organizations of national scope and interested in the geological sciences have ratified the Articles of Organization, appointed two directors each, and constitute the present member organizations; other non-profit organizations of national scope may be admitted as member organizations; local, regional, or national non-profit organizations interested in the geological sciences may be admitted to affiliate membership; and any organization interested in the geological sciences and which contributes to the support of the Institute, may be admitted to associate membership. The Institute is organized within the framework of the National Research Council, which is an agency of the National Academy of Sciences.

The other officers of the Institute are: William B. Heroy, vice-president, and Earl Ingerson, secretary-treasurer. The officers, together with Arthur Bevan, chairman of the Division of Geology and Geography of the National Research Council, constitute the executive committee. The directors appointed by the American Association of Petroleum Geologists are Paul Weaver and William B. Heroy.

[1] Read before the Association at St. Louis, March 17, 1949. Manuscript received, April 2, 1949.

[2] President, American Geological Institute; dean, School of Mineral Sciences, Stanford University.

Geology in its broader aspects is daily becoming more technical in its methods, more complex and specialized in its interests, and more important in human affairs. The formation of the Institute provides a means of cooperation in many diverse areas which are important, but which formerly lacked coordination with one another. Some of these areas are indicated by the standing committees, of which seven have been set up so far to carry out the objectives as follows.

I. *Education Committee.*—To provide coordination of the entire field of education in the earth sciences in America.

II. *Personnel Committee.*—To be responsible for the continuing study of the supply and demand of geologically trained personnel and manpower for education, research, government, and industry (including military and civilian requirements).

III. *Publications Committee.*—To explore means of improving the geological publications, decrease the cost of publication, and promote the writing and publication of geological articles and books of general public interest.

IV. *Research Information Committee.*—To provide coordination of research in the earth sciences.

V. *Public Relations Committee.*—To promote public understanding and appreciation of geology and its uses.

VI. *Government Relations Committee.*—To develop and recommend to the Institute and its officers, policies with respect to:

(a) Counselling with and giving advice to governmental agencies in the fields of the earth sciences, and

(b) Keeping member organizations informed on matters of governmental programs that may affect the member organizations.

VII. *Finance Committee.*—To be responsible for the soliciting and receiving of funds in the name of the Institute. All funds received are turned over to the National Research Council where they are available for use as needed.

One goal of geology is that is should take its place along with the other sciences in forming a united front in the service of mankind. The interdependence of all the sciences is becoming daily more apparent. In order that it might do this most effectively, the Institute is organized as "an instrument of the National Research Council," thereby uniting with all of the other American sciences in seeking solutions to those problems which can be attacked best through group or united action. The purpose of the National Research Council, which is the principal operating agency of the National Academy of Sciences, is to promote research in the sciences and to serve as an adviser to governmental and other organizations.

National problems of mineral discovery, supply, conservation, and resources are of great public concern whether we are at peace or at war—and they are fundamentally geological in nature. Moreover, they are often not well understood. Delo expressed our public responsibility well when he stated, "So long as we are a democracy, our ultimate strength will be dependent on the comprehension of national problems by the average voter." Affiliation with the National Research Council immediately places the Institute on the front line along with all of the other sciences in attacking those national problems where we can make a contribution.

In order to implement the programs of the standing committees and to coordinate the work of our Institute with that of the other sciences, a full-time permanent secretary will be necessary. Office space will be provided by the National Research Council in the Academy of Sciences building in Washington. The futility of people busy with other full-time jobs in other parts of the country attempting to get anywhere in furthering the aims of the Institute is apparent to all of the directors. One of the first jobs of the directors, therefore, is to arrange for the finances and select such a secretary. It is an important post, and the sooner we can get it into operation, the sooner we can begin to function.

The officers and directors of the Institute feel strongly that we have a great opportunity of doing something really worthwhile for the geological sciences; of assuring geology a higher place in the councils of government; and of making the American Geological Institute the focal point of contact between the geological sciences and the public. There is much work to be done and with the continuing backing of the geologists of America we believe it will pay rich dividends to all.

THIRTY-FOURTH ANNUAL MEETING, ST. LOUIS, MARCH 14–17, 1949
TECHNICAL PROGRAM

MONDAY NIGHT, MARCH 14

RESEARCH COMMITTEE SYMPOSIUM

CONTROL OF OIL AND GAS ACCUMULATION BY SEDIMENTARY FACIES

JOHN T. ROUSE, *presiding*

1. Stevens Sand (Miocene), Southern San Joaquin Valley, California
   Pacific Section Research Committee[1]
2. Wilcox to Cockfield (Eocene), Louisiana Gulf Coast
   Max Bornhauser
3. Newcastle Sand (Upper Cretaceous), Wyoming
   H. E. Summerford, E. E. Schieck, T. C. Hiestand
4. Paluxy (Lower Cretaceous), East Texas
   East Texas Geological Society Research Committee[2]
5. Hugoton Gas Field, Kansas, Oklahoma, and Texas
   Garvin L. Taylor and R. J. Riggs
6. Waltersburg Sand (Mississippian) of Wabash Valley, Illinois
   David H. Swann
7. Facies Background of Appalachian Accumulation
   Frank M. Swartz

[1] E. R. Atwill, F. B. Carter, H. L. Driver (chm.), Rollin Eckis, S. C. Herold, G. W. Ledingham, R. G. Reese, R. R Simonson, H. W. Weddle, W. P. Winham.

[2] T. C. Cash, J. M. DeLong, H. H. Lester (chm.), R. M. Trowbridge.

TUESDAY MORNING, MARCH 15

PRESIDENTIAL ADDRESSES AND HONORS. JOINT SESSION

PAUL WEAVER AND L. L. NETTLETON, *presiding*

1. Introduction
2. Geological Interpretation of Exploratory Wells
   Paul Weaver, president of A.A.P.G., Gulf Oil Corporation, Houston, Texas
3. Trends in Sedimentology.
   R. Dana Russell, president of S.E.P.M., United States Navy Electronics Laboratory, San Diego, California
4. Geophysics, Geology, and Oil Exploration
   L. L. Nettleton, president of S.E.G., Gravity Meter Exploration Company, Houston, Texas
5. Presentation of Honors
   A.A.P.G. President's Award
   Recipient
   Sherman A. Wengerd, University of New Mexico, Albuquerque, New Mexico
   A.A.P.G. Honorary Membership
   Honorees
   G. Clark Gester, Standard Oil Company of California, San Francisco, California
   Citation by Roy M. Barnes
   F. M. Van Tuyl, Colorado School of Mines, Golden, Colorado
   Citation by Carroll E. Dobbin

TUESDAY AFTERNOON, MARCH 15

PAPERS OF GENERAL INTEREST. JOINT SESSION

ROY M. BARNES AND ANDREW GILMOUR, *presiding*

1. Geophysical Activity in 1948
   E. A. Eckhardt, Gulf Research and Development Company, Pittsburgh, Pennsylvania
2. Precision Gravity Survey of Jameson Area, Coke County, Texas
   Hart Brown, Brown Geophysical Company, Houston, Texas
3. Paleo-Temperatures of Cretaceous and Jurassic
   Harold C. Urey, Institute of Nuclear Physics, University of Chicago, Chicago, Illinois
4. Statistical Study of Accuracy of Some Connate Water Resistivity Determinations Made from Self-Potential Log Data
   M. R. J. Wyllie, Gulf Research and Development Company, Pittsburgh, Pennsylvania

5. Limestone Development in Pennsylvanian of Eastern Permian Basin
   Frank B. Conselman, consulting geologist, Abilene, Texas
   J. N. Conley, Seaboard Oil Company, Abilene, Texas
6. Geophysical Exploration for Limestone Reefs
   F. J. Agnich, Geophysical Service, Inc., Dallas, Texas

WEDNESDAY MORNING, MARCH 16

EXPLORATORY DRILLING AND FIELD PAPERS
THERON WASSON AND CLIFTON W. JOHNSON, *presiding*

1. Exploratory Drilling in 1948
   F. H. Lahee, Sun Oil Company, Dallas, Texas
2. Evaluation of Permeability from a Determination of the Resistivity Gradient on the Electric Logs
   M. P. Tixier, Schlumberger Well Surveying Corporation, Denver, Colorado
3. Continental Shelf Exploration Off Louisiana and Texas
   Dean A. McGee, Kerr-McGee Oil Industries, Inc., Oklahoma City, Oklahoma
4. Exploration Policies in Kansas, 1928–1948
   Edward A. Koester, consulting geologist, Wichita, Kansas
5. Mayfield Pool, Cuyahoga County, Ohio
   Howard E. Rothrock, United States Geological Survey, Washington, D. C.
6. Commercial Oil from Cambrian Beds in Lost Soldier Field, Wyoming
   E. W. Krampert, consulting geologist, Casper, Wyoming

WEDNESDAY AFTERNOON, MARCH 16

SYMPOSIUM ON REEFS
HOLLIS D. HEDBERG AND KENNETH K. LANDES, *presiding*

Reef Definition
W. B. Wilson, Gulf Oil Corporation, Tulsa, Oklahoma

1. Organic Reefs in the Geologic Column
   W. H. Twenhofel, Orlando, Florida
2. Modern Reefs
   Harry S. Ladd, United States Geological Survey, Washington, D. C.
3. Observations on Cretaceous and Tertiary Reef Formations and Associated Sediments in Middle East
   F. R. S. Henson, Iraq Petroleum and Associated Companies, Geological Research Centre, London, England
   (Read by D. A. Greig, Standard Oil Company (New Jersey), New York City)
4. Pennsylvanian Reef at Todd Field, Crockett County, Texas
   Robert F. Imbt, consulting geologist, Fort Worth, Texas
   S. V. McCollum, Continental Oil Company, Fort Worth, Texas
5. Theory of Transgressive and Regressive Reef (Bioherm) Development and Origin of Oil within Them
   Theodore A. Link, geologist, Toronto and Calgary, Canada
6. Devonian Dolomitized Reef, D-3 Reservoir, Leduc Field, Alberta, Canada
   W. W. Waring and D. B. Layer, Imperial Oil Limited, Calgary, Alberta

WEDNESDAY NIGHT, MARCH 16

PAUL WEAVER, *presiding*

Atomic Energy and Its Relation to Geology
Sumner T. Pike, United States Atomic Energy Commission, Washington, D. C.
(Introduced by E. DeGolyer, Dallas, Texas)

THURSDAY MORNING, MARCH 17

FOREIGN PAPERS
LEWIS G. WEEKS AND THOMAS A. HENDRICKS, *presiding*

1. Brazilian Oil Fields and Oil-Shale Reserves
   S. Froes Abreu, Mineral Industries Division, Rio de Janeiro, Brazil
2. Devonian and Mississippian Stratigraphy, Wapiti Lake Area, British Columbia
   L. R. Laudon, Elgin Diedrick, Edwin Grey, Warren Hamilton, Paul J. Lewis, William McBee, A. G. Spreng, and Roger Stoneburner, University of Wisconsin, Madison, Wisconsin

3. Salina-Guelph Fields of Southwestern Ontario
   W. A. Roliff, Imperial Oil Ltd., Toronto, Canada
4. Bahamas Deep Test
   Maria Spencer, Bahamas Oil Company, Ltd., Nassau, Bahamas
5. Geology and Petroleum Exploration in Magallanes Province, Chile
   C. R. Thomas, Corporacion de Fomento de la Produccion Chile, Punta Arenas, Chile
   (Read by Clark Millison, consulting geologist, Tulsa, Oklahoma)
6. Can Ancient Continental-Slope Deposits Be Recognized by Intrastratal Flow Phenomena and a Special Type of Bedding?
   John L. Rich, University of Cincinnati, Cincinnati, Ohio

THURSDAY AFTERNOON, MARCH 17

TECHNICAL SESSION
M. M. LEIGHTON AND L. M. CLARK, *presiding*

1. American Geological Institute
   A. I. Levorsen, President of A.G.I., School of Mineral Sciences, Stanford University, California
2. Sedimentary Tectonics and Sedimentary Environments
   W. C. Krumbein, E. C. Dapples, and L. L. Sloss, Northwestern University, Evanston, Illinois
3. Pore Space Reduction in Sandstones
   Jane M. Taylor, United States Engineers, Cincinnati, Ohio
4. Where and What Is the Appalachian Basement?
   Ernst Cloos, Johns Hopkins University, Baltimore, Maryland
5. Structure and Thickness of Athens Shale
   Charles E. Decker, University of Oklahoma, Norman, Oklahoma
6. Mineralogical and Bacterial Content of Some Paleozoic Shales of Missouri
   Victor T. Allen and Albert J. Frank, Institute of Technology, St. Louis University, St. Louis, Missouri
   Joseph J. Fahey, United States Geological Survey
7. Oolitic Facies of Middle Mississippian Ste. Genevieve Formation in Indiana
   Carlton J. Leith, Indiana University, Bloomington, Indiana

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MINUTES, THIRTY-FOURTH ANNUAL BUSINESS MEETING ST. LOUIS, MARCH 17, 1949

PAUL WEAVER, *Presiding*

The meeting was called to order at 4:00 P.M., Thursday, March 17, 1949, in the Gold Room of the Jefferson Hotel, St. Louis, Missouri, by president Paul Weaver.

1. *Reports of officers.*—The reports of president Paul Weaver, secretary-treasurer J. V. Howell, and editor C. L. Moody appear as Exhibits I, II, and III.

2. *Incoming officers.*—President Weaver introduced the incoming officers: president, C. W. Tomlinson, Ardmore, Oklahoma; vice-president, Theodore A. Link, Calgary, Alberta; secretary-treasurer, Henry A. Toler, Jackson, Mississippi; editor, Alfred H. Bell, Urbana, Illinois.

3. *Report of business committee.*—The report of the business committee was read by its chairman, A. L. Selig (Exhibit IV).

It was moved and seconded that the report be adopted. After extended discussion, including the loss of a motion to amend so as to consider parts of the report separately (92 against; 76 for), and the loss of a motion to table the report (109 against; 43 for), the original motion to adopt the report carried.

(The following reports appear as exhibits in the minutes)

I. President, Paul Weaver
II. Secretary-treasurer, J. V. Howell
III. Editor, C. L. Moody
IV. Business, A. L. Selig, chairman
V. National Research Council, Philip B. King, representative

VI. Stratigraphic nomenclature, Wayne V. Jones, chairman
VII. Publication, Geo. C. Grow, Jr., chairman
VIII. Research, John T. Rouse, chairman
IX. Geologic names and correlations, Henry J. Morgan, chairman
X. Applications of geology, R. A. Stehr, chairman
XI. Medal award, Paul Weaver, chairman
XII. Statistics of exploratory drilling, F. H. Lahee, chairman
XIII. Distinguished lectures, Fred H. Moore, chairman
XIV. Boy Scouts literature, Frank Gouin, chairman
XV. National responsibility of geologists, O. F. Kotick, chairman

The meeting adjourned at 5:00 P.M.

PAUL WEAVER, *chairman* — J. V. HOWELL, *secretary*

EXHIBIT I. REPORT OF PRESIDENT

During the year just completed, the president had the opportunity to attend the regional meetings at Pittsburgh and Houston, and the Pacific Section meeting at Pasadena, as well as the joint meeting of the South Texas Section and the Geological Society of Mexico at Mexico City. A meeting of the Eastern Section at New York City was also attended. In addition, two field trips, one by the Wyoming Geological Association and one by the Shreveport Geological Society, were also visited. It was possible to attend meetings of a number of the affiliated societies, but I regret that it was not possible to meet with the members of all of them.

I wish to express my appreciation of the privilege of discussing Association affairs and the work of its committees with so many of our members. Every request for assistance in committee work was received with very cooperative response, and it is to these members who were consulted that the Association and the executive committee owe much of the results obtained during the year.

To the headquarters staff under Mr. Hull, and to the program committee for this meeting under Mr. Wilson, I wish to express my gratitude for the meeting here in St. Louis.

The privilege of knowing better so many of the members will remain with me as an opportunity for which I wish to thank you.

PAUL WEAVER, *president*

EXHIBIT II. REPORT OF SECRETARY-TREASURER
(Year Ending March 1, 1949)

Last year the secretary reported the largest growth in membership in the history of the Association. This year even that record has been broken with a net increase of 731 new and re-instated members as compared with 550 in the year ended on March 1, 1948. The total has now reached 6,160, with 421 applications on hand at March 1.

The large increment has been due not only to increased enrollment in colleges and universities, but to other factors as well. This year 347 of the new members were associates, while 281 applied for active status, the latter constituting 45.6 per cent of the year's increase, whereas in the previous year 64 per cent of accretions were active members. More graduate and undergraduate students are applying for membership prior to completion of their school work, and increasing numbers of men with no specific geological training are applying also.

This rapid increase in numbers is not an unmixed blessing, particularly to the office staff and the executive committee, who are charged with the duty of investigating each applicant. When the Association was smaller, the officers knew most of the sponsors, but to-day it is more usual for applicant, sponsors, and references to be unknown to anyone on the committee, so that a decision must be made solely on the basis of the information

furnished on the 10–15 written forms. The physical task of assembling these data is tremendous, and the burden of reading it is not small.

On the financial side, it should be pointed out that the cost of processing applications is large, perhaps as much as $3.00 each. Also each new member receives the *Bulletin* for one year (cost $8.72), and his share of other services of the Association, costing this year $11.35. This is a total cost of $20.00 per member for which the Association receives only $6.00 in the case of an associate and $10.00 for an active member. New members are not profitable financially and only by future value to the Association can their election be justified. Care in selection is a necessity.

It is with deep regret that we note the deaths of 28 members, associates, and honorary members. They are the following.

MEMBERS AND ASSOCIATES DECEASED

(Reported Since Last Annual Meeting)

Honorary

Emmons, William H., November 5, 1948

Active

Banks, Thomas R., September 22, 1948
Brown, James Chapman, March 27, 1948
Clark, Robert W., June 5, 1948
Collom, Roy E., September 25, 1948
Dodson, Floyd C., January 30, 1949
Drake, Cecil, January 31, 1949
Eyssell, Alfred R., June 28, 1944
Fowler, Charles W., Jr., September 30, 1948
Giltinan, George M., August 3, 1948
Hall, Elwin B., January 20, 1949
Knox, T. K., March 10, 1949
May, Arthur R., December 9, 1948
Ogg, Thomas A., Jr., January 16, 1949
Palmer, Robert H., May 14, 1948
Peterson, Clarence J., May 8, 1948
Porch, Edwin L., Jr., June 9, 1948
Rieber, Frank, June 30, 1948
Robinson, Bryan F., January 5, 1949
Scott, Gayle, May 2, 1948
Senn, Alfred, Jr., January 29, 1949
Stewart, James Smith, October 28, 1948
Stilley, Earl M., December 27, 1948
Swain, James F., October 4, 1948
Welch, Virgil H., September 6, 1948

Associate

Johnson, Harold G.,
Leavitt, William B., June 24, 1948
Wilsey, James A., Jr., January 10, 1949

Income.—The income of the Association again reached a new peak, and happily outstripped somewhat the increased cost of operation. An all-time high income of $141,142.18 and an all-time high expense of $123,240.52 leaves us with an apparent profit of $17,901.66. Both high income and high costs are due largely to current inflation, for dues have not been increased. The favorable result was due wholly to an increase of $18,328.68 in advertising revenue and of $1,155.41 in return from investments. Without these items we would have shown a small operating loss.

Effective January 1, 1948, advertising rates were increased to reflect the greater circulation, and this increase has been in effect for the full year. Concurrently Mr. Ellsworth has devoted much time to obtaining additional advertising, with the favorable results indicated. It is doubtful if much further increase can be or should be sought, but the present volume should be maintained. Only by this means can the number of pages in the *Bulletin* be further increased and dues be kept at present levels.

The *Bulletin* costs continue to increase, as shown in Table VIII. The *Bulletin*, in 1948, printed 2,370 pages of text, an increase of 102 pages over the previous year, and 251 over 1946. Meantime, costs rose from $6.78 per year to $8.72 per year, which indicate that all associates are being carried at a loss, and that active members are barely paying for their *Bulletins*. This is another argument for greater selectivity in membership.

Investment.—Little change was made in investments during the past year other than minor shifts. The total of invested funds increased $21,153.84, partly through stock dividends, partly from surplus funds, and investment of life membership payments.

Approximately $80,000 are invested in United States Government bonds, or 44 per

cent of the total. The remainder is largely invested in high-grade common and preferred stocks. Income rate on the bonds is $2\frac{1}{2}$ per cent only, but that from the stocks was sufficient to produce a return of 4.45 per cent on the over-all investment, at cost. This is comparable with 4 per cent in the previous year.

Total assets of the Association are now $274,779,48.

The future.—It is hoped that the peak of costs has been reached, but of this there is no certainty. Certain measures in Congress threaten to increase the postal rates on such publications as the *Bulletin* by 100–300 per cent, which could mean an increased cost of $2,000–$4,000 per year. Headquarters staff must be increased each year to care for growing membership, since each 500 new members requires one new clerk or stenographer. This, if continued will necessitate more office space. And the *Bulletin* may need to be increased in size if the ratio of papers to members continues to hold. The nest egg produced this year may well be needed before another year has elapsed, particularly if the A.G.I. begins to function and also requires our support.

Executive committee meetings were held on the following dates.

Denver, Colorado	April 30, 1948
Tulsa, Oklahoma	May 21, 1948
Lander, Wyoming	August 11, 1948
Pittsburgh, Pennsylvania	October 3–5, 1948
New York, New York	November 14, 1948
Houston, Texas	December 3, 1948
Tulsa, Oklahoma	February 3–4, 1949
St. Louis, Missouri	March 13 and 18, 1949

At Pittsburgh and New York only three members (a quorum) were present and routine matters only were considered. At the remaining sessions all members of the committee were present.

Too much credit can not be given to the Headquarters staff for their loyal and efficient handling of the Association affairs. The handicaps of moving and settling down in new quarters together with the rapid increase in work have not been enough to lower efficiency, and as the year ends work is up-to-date. To Messrs. Hull and Ellsworth and their staff the secretary-treasurer expresses not only his appreciation but that of the executive committee for a big job well done.

J. V. Howell, *secretary-treasurer*

TABLE I

Total Membership by Years

May 19, 1917	94	March 1, 1933	2,336
February 15, 1918	176	March 1, 1934	2,043
March 15, 1919	348	March 1, 1935	1,973
March 18, 1920	543	March 1, 1936	2,169
March 15, 1921	621	March 1, 1937	2,331
March 8, 1922	767	March 1, 1938	2,646
March 20, 1923	901	March 1, 1939	2,951
March 20, 1924	1,080	March 1, 1940	3,240
March 21, 1925	1,253	March 1, 1941	3,474
March 1, 1926	1,504	March 1, 1942	3,717
March 1, 1927	1,670	March 1, 1943	3,923
March 1, 1928	1,952	March 1, 1944	4,109
March 1, 1929	2,126	March 1, 1945	4,326
March 1, 1930	2,292	March 1, 1946	4,676
March 1, 1931	2,562	March 1, 1947	5,039
March 1, 1932	2,558	March 1, 1948	5,530
		March 1, 1949	6,160

TABLE II

COMPARATIVE DATA OF MEMBERSHIP

	March 1, 1948		*March 1, 1949*	
Number of honorary members	16		14	
Number of life members	15		18	
Number of members	4,185		4,466	
Number of associates	1,314		1,662	
Total number of members and associates		5,530		6,160
Net increase in membership		491		630
Total new members and associates	525		708	
Total reinstatements	25		23	
Total new members and reinstatements		550		731
Applicants elected, dues unpaid	16		53	
Applicants approved for publication	63		171	
Recent applications	170		197	
Total applications on hand		249		421
Applicants for reinstatement elected, dues unpaid	0		1	
Recent applications for reinstatement	2		4	
Total applications for reinstatement on hand		2		5
Applicants for transfer approved for publication	22		22	
Recent applications for transfer on hand	36		20	
Total applications for transfer on hand		58		42
Applications for life membership on hand		2		0
Number of members and associates resigned	22		14	
Number of members and associates dropped	25		62	
Number of members and associates died	12		25	
Total loss in membership	59		101	
Total gain in membership		550		731
Number of members and associates in arrears, previous years	95		82	
Members in arrears, current year	425		389	
Associates in arrears, current year	183		194	
Total number members and associates in arrears, current year		608		583
Total number members and associates in good standing		4,827		5,495

TABLE III

Geographic Distribution of Members

March 1, 1949

Alabama	18	Louisiana	358	North Dakota	4
Arizona	12	Maryland	9	Ohio	48
Arkansas	23	Massachusetts	23	Oklahoma	760
California	686	Michigan	57	Oregon	7
Colorado	214	Minnesota	10	Pennsylvania	90
Connecticut	9	Mississippi	81	South Carolina	2
Delaware	2	Missouri	30	South Dakota	8
Dist. of Columbia	73	Montana	35	Tennessee	13
Florida	31	Nebraska	8	Texas	1,984
Georgia	5	Nevada	2	Utah	31
Idaho	3	New Hampshire	1	Virginia	8
Illinois	123	New Jersey	18	Washington	17
Indiana	56	New Mexico	83	West Virginia	22
Iowa	16	New York	132	Wisconsin	10
Kansas	200	North Carolina	6	Wyoming	142
Kentucky	32				

Total members in United States 5,502

Alaska	2	Denmark	6	Nova Scotia	1
Alberta	90	Egypt	15	Ontario	21
Algeria	4	England	13	Palestine	1
Angola	1	Ethiopia	2	Panama	4
Argentina	11	France	12	Papua	1
Australia	9	Germany	2	Paraguay	2
Austria	2	Guam	1	Persian Gulf	7
Bahamas	1	Guatemala	4	Peru	18
Barbados	1	Hawaii	1	Philippine Islands	3
Belgian Congo	1	Hungary	1	Portugal	1
Belgium	1	India	4	Puerto Rico	1
Bolivia	1	Iraq	1	Quebec	1
Borneo	2	Italy	4	Saskatchewan	3
Brazil	12	Japan	1	Saudi Arabia	10
British Columbia	4	Java	1	Spain	1
British Guiana	1	Mexico	15	Sumatra	7
British Somaliland	1	Morocco	2	Switzerland	13
Burma	1	Mozambique	1	Syria	12
Chile	9	Netherlands	15	Tasmania	1
China	3	New Brunswick	1	Trinidad	11
Colombia	66	New Zealand	2	Tunisia	1
Costa Rica	1	Nicaragua	1	Turkey	5
Cuba	4	Nigeria	1	Venezuela	199

Total members in foreign countries 658

Grand total 6,160

TABLE IV

COMPARISON OF ACCRUED INCOME BY CALENDAR YEARS

	1946	1947	1948
Dues			
Members	$38,590.00	$ 41,580.00	$ 44,760.00
Associates	8,304.00	9,438.00	11,172.00
Total	$46,894.00	$ 51,018.00	$ 55,932.00
Bulletin			
Subscriptions	$ 6,752.49	$ 7,716.30	$ 8,970.15
Advertising	22,591.73	22,520.10	40,848.78
Total	$29,344.22	$ 30,236.40	$ 49,818.93
Back Numbers, etc.			
Bound Volume of Bulletin	$ 3,139.75	$ 2,900.20	$ 4,909.60
Back Numbers of Bulletin	3,077.16	2,765.87	4,733.47
Other Publications	413.19	174.82	294.96
Total	$ 6,630.10	$ 5,840.89	$ 9,938.03
Special Publications			
Geology of Natural Gas*	$ 124.20	$ —	$ —
Geology of Tampico Region*	323.45	294.35	327.45
Gulf Coast Oil Fields*	89.80	3.00	—
Map of Southern California*	49.60	37.05	58.20
Miocene Stratigraphy of California*	510.05	504.00	671.00
Stratigraphic Type Oil Fields*	1,606.70	812.55	—
Source Beds of Petroleum*	598.50	182.75	—
Possible Future Oil Provinces	245.65	398.60	363.75
Comprehensive Index	—	6,077.00	1,349.40
Tectonic Map of United States	2,184.85	1,323.00	1,441.85
Directory, Geol. Inf. in North America	76.50	223.50	258.75
Structure of Typ. Amer. Oil Fields, Vol. I*	—	2,928.00	156.00
Structure of Typ. Amer. Oil Fields, Vol. II*	—	3,704.00	344.00
Structure of Typ. Amer. Oil Fields, Vol. III*	—	—	6,892.99
Appalachian Basin Ordovician Symposium	—	—	256.10
Total	$ 5,809.30	$ 16,487.80	$ 12,119.49
Other Income			
Delinquent Dues Charged Off	$ 886.49	$ 401.07	$ 421.75
Interest, General Fund	3,767.94	5,463.86	6,448.85
Interest, Publication Fund	817.00	880.68	1,005.17
Interest, Research Fund	33.99	17.40	42.58
Interest, Powers Medal Fund	233.95	232.50	232.50
Profit, Sale of Investments, General	245.00	1,106.92	—
Profit, Sale of Investments, Publication	—	1,689.78	—
Profit, Sale of Investments, Research	91.97	—	—
Miscellaneous	158.73	219.17	226.00
Sale of Library	5.00	19.50	—
Members Reinstated	20.00	34.00	—
Inventory Increase	—	10,369.80	4,956.88
Donations, Powers Medal Fund	100.00	—	—
Total	$95,037.69	$124,017.77	$141,142.18

* Income of Publication Fund.

TABLE V

Comparison of Accrued Expenses by Years

	1946	*1947*	*1948*
General and Administrative Expenses			
Salaries—Managerial and Clerical	$14,142.80	$ 15,521.10	$ 19,152.63
Payroll Taxes	275.86	456.85	426.08
Rent	2,485.50	3,971.50	4,690.50
Telephone and Telegraph	569.44	450.34	687.39
Postage	2,904.71	3,376.20	3,990.30
Office Supplies and Expenses	790.62	944.85	1,765.51
Printing and Stationery	1,086.27	822.08	1,548.89
Audit Expense	300.00	300.00	300.00
Insurance	248.47	328.92	329.36
Freight and Express	213.17	291.93	351.77
Convention Expense (Net)	1,089.97	508.73	1,338.95
Bad Debts	802.26	744.23	549.01
Miscellaneous	683.06	504.88	579.08
Depreciation—Furniture and Fixtures	1,466.18	307.20	1,099.47
Investment Counsel	400.00	400.00	200.00
Traveling Expenses	1,899.00	175.24	1,190.39
Research Projects and Expense	2,414.21	3,166.50	1,098.11
Review of Petroleum Geology	—	—	1,408.88
Donation—Society Econ. Paleon. and Mineral	1,500.00	2,000.00	—
Distinguished Lecture Committee	500.00	—	—
National Service Committee	—	116.49	104.25
Powers Medal Expense	—	248.29	248.25
President's Award	100.00	100.00	100.00
Moving Expense	—	1,137.83	297.95
Committee on App. of Geol.	—	193.00	306.10
Loss, Sale of Investments, General	—	—	1,992.20
Rock Color Chart	—	—	500.00
Total	$33,871.52	$ 36,066.16	$ 44,255.07
Publication Expenses			
Salaries—Managerial and Editorial	$ 9,073.11	$ 12,630.00	$ 13,250.00
Printing Bulletin	25,965.83	32,914.84	39,969.62
Engravings	2,337.40	3,233.75	3,682.99
Separates	615.44	1,383.64	209.75
Stencils and Mailing	112.54	106.61	140.60
Binding Bulletins	836.73	912.59	1,324.21
Postage and Express (Bulletins)	1,170.20	1,383.94	2,192.73
Copyright Fees	24.00	24.00	38.00
Freight, Express, Postage (Other Publications)	131.05	327.09	330.33
Miscellaneous	45.73	13.57	31.64
Special Publications	1,958.49	19,592.16	13,243.59
Special Publication Inventory Decrease	3,256.83	—	—
Special Insert Charges	2,532.49	2,739.01	4,571.99
Total	$48,059.84	$ 75,261.20	$ 78,985.45
Total Expense	$81,931.36	$111,327.36	$123,240.52

TABLE VI

Comparison of Net Income by Years

	1946	*1947*	*1948*
Accrued Income	$95,037.69	$124,017.77	$141,142.18
Expenses			
General and Administrative	$33,871.52	$ 36,066.16	$ 44,255.07
Publication	48,059.84	75,261.20	78,985.45
Total	$81,931.36	$111,327.36	$123,240.52
Excess Income over Expenses	$13,106.33	$ 12,690.41	$ 17,901.66

TABLE VII

INVESTMENTS

	Cost	Market Value End of Year
1946 Values		
General Fund	$109,635.48	$110,698.12
Publication Fund	29,632.21	30,299.39
Research Fund	1,736.81	1,736.81
Powers Medal Fund	9,300.00	8,916.60
Life Membership Fund	2,800.00	2,707.20
Total	$153,104.50	$154,358.12
1947 Values		
General Fund	$122,774.97	$126,023.51
Publication Fund	27,862.14	26,191.61
Research Fund	1,754.21	1,754.21
Powers Medal Fund	9,300.00	8,816.40
Life Membership Fund	2,800.00	2,677.60
Total	$164,491.32	$165,463.33
1948 Values		
General Fund	$132,890.47	$136,864.31
Publication Fund	34,932.88	32,657.11
Research Fund	4,731.81	4,965.54
Powers Medal Fund	9,300.00	8,807.10
Life Membership Fund	3,800.00	3,648.80
Total	$185,655.16	$186,942.86

TABLE VIII

COMPARISON OF COST OF BULLETIN

	1946	1947	1948
Total Expenses	$42,713.47	$55,341.95	$65,411.53
Monthly Edition	6,300	7,000	7,500
Total Copies Printed	75,600	84,000	90,000
Total Pages Printed, including covers	2,776	3,022	3,162
Total Pages of Text	2,119	2,268	2,370
Total Cost per Copy	0.565	0.659	0.727

TABLE IX

(Section 1)

SPECIAL PUBLICATIONS

	Geology Tampico Region (1936)	Tectonic Map of California (1936)	Miocene Stratigraphy of California (1938)	Possible Future Oil Provinces (1941)	Total
Inventory					
Dec. 31, 1947	$ 618.30	$ 9.76	$ 980.10	$ 308.74	$1,916.90
Dec. 31, 1948	423.65	—	618.75	172.89	1,215.29
Sales	327.45	58.20	671.00	363.75	1,420.40
Total Edition	1,575	940	1,530	4,097	
Copies on Hand					
Dec. 31, 1947	270	122	396	718	
Dec. 31, 1948	185	—	250	403	
Number of Pages	280	—	450	154	
Cost (inventory) per copy	$ 2.29	$ 0.08	$ 2.475	$ 0.429	
Selling Price					
Members and Associates	3.50	0.50	4.50	1.00	
Non-Members	4.50	0.50	5.00	1.50	

TABLE IX

(Section 2)

SPECIAL PUBLICATIONS

	Stratigraphic Type Oil Fields (1942)	*Source Beds of Petroleum (1942)*	*Tectonic Map of U.S. (1944)*	*Dir. Geol. Mat. in N.A. (1946)*	*Total*
Inventory					
Dec. 31, 1947	$ 28.22	$ 34.30	$1,907.91	$ 246.56	$2,216.99
Dec. 31, 1948	18.97	—	945.23	185.14	1,149.34
Sales	15.50	56.40	1,441.85	258.75	1,772.50
Total Edition	2,526	1,539	7,000	1,817	
Copies on Hand					
Dec. 31, 1947	10	14	1,530	1,393	
Dec. 31, 1948	7	—	758	1,046	
Number of Pages	902	566	—	111	
Cost (inventory) per copy	$ 2.71	$ 2.546	$ 1.247	$ 0.177	
Selling Price					
Members and Associates	4.50	3.50	1.75	0.75	
Non-Members	5.50	4.50	1.75	0.75	

TABLE IX

(Section 3)

SPECIAL PUBLICATIONS

	Structure of Typ. Amer. Oil Fields Vol. I (1929)	*Structure of Typ. Amer. Oil Fields Vol. II (1929)*	*Structure of Typ. Amer. Oil Fields Vol. III (1948)*	*Index to AAPG Publications (1947)*	*Appal. Basin Ordovician Symposium (1948)*	*Total*
Inventory						
Dec. 31, 1947	$ 119.70	$ 259.35	$ —	$11,002.82	$ —	$11,381.87
Dec. 31, 1948	20.90	30.03	8,569.00	7,431.58	539.61	16,591.12
Sales	156.00	344.00	6,892.99	1,349.40	256.10	8,998.49
Total Edition	1,039	1,027	6,033	6,067	1,035	
Copies on Hand						
Dec. 31, 1947	63	95	—	4,104	—	
Dec. 31, 1948	11	11	4,100	3,679	875	
Number of Pages	510	780	516	603	1,657	
Cost (inventory) per copy	$ 1.90	$ 2.73	$ 2.09	$ 2.02	$ 0.617	
Selling Price						
Members and Associates	3.00	4.00	3.50	3.00	1.50	
Non-Members	3.00	4.00	4.50	4.00	2.00	

EXHIBIT III. REPORT OF EDITOR

When the December, 1948, issue of the *Bulletin* rolled from the press thirty-two (32) volumes, consisting of 303 numbers had been added to the world's library of periodical geologic literature through the publication activities of the Association. Almost 46,000 pages of printed matter setting forth the rise and progress of petroleum geology are bound in this imposing shelf of books. Major articles numbering 1,838, together with nearly 700 geologic notes and hundreds of discussions, reviews, memorials, and news items of Association affairs, are here recorded for the benefit of the generations of petroleum geologists who will succeed us. It is well to give thought to the fidelity with which records of the ideas, accomplishments, and frustrations, if any, of our times are preserved for our successors. By this measure only will we be appraised by posterity. But not only as a monument recording departed greatness is the *Bulletin* important to us; it also currently serves in the dissemination of knowledge, theory, and belief generally regarded as of fundamental pres-

ent usefulness in exploration for petroleum. How well these purposes are served depends on the responsibility assumed by the membership, on the efficient functioning of the executive, editorial, and headquarters staffs of the Association, and, above all, on the loyalty, enthusiasm, and technical proficiency of those whose writings fill the pages of our publications.

Membership responsibility with respect to *Bulletin* welfare may be expressed by willingness to serve in committee work, in editorial work, and in executive work; by constructive criticism of long-range publication policies, as well as of current issues; by favorable response to requests for written contributions, and especially by submitting unsolicited papers for use as *Bulletin* material.

The completed thirty-two volumes of *Bulletins* and the twenty-two special publications issued under the authority of executive committees have been editorially supervised by eighty-five different men functioning in various capacities. Sixty-five have served, or are now serving, as associate editors; ten others have been concerned only with special publications; ten, including two who had been associate editors, have held the elective office of editor. Membership response to the official call to publication duty would seem to have been adequate. The response to the invitation to authorship has just been sufficient to maintain a balanced *Bulletin*.

The twelve issues of Volume 32 contain 2,361 pages, the largest number yet printed in a single year. They comprise eighty-seven major articles, thirteen geologic notes, three discussions, sixteen reviews, and nine memorials. The pages record contributions from 156 different writers; 106 of them are the authors or co-authors of the 87 major articles. The papers printed do not fully measure membership interest in writing for the *Bulletin*. About ten per cent of the manuscripts offered for editorial scrutiny were rejected, and ten per cent were returned to the authors for revision. Furthermore, a sufficient number of manuscripts of 1948 origin has been accepted and approved for publication to fill available *Bulletin* space through the summer of 1949. Also, over eight per cent of our 1948 authors are not members of the Association. From these observations, it may be concluded that about three per cent of our members made direct or indirect contribution to *Bulletin* contents during 1948. All-time author responsibility has been assumed by about twenty-six per cent of our total membership.

Who wrote the major papers in our last volume? The authors' vocational affiliations, announced in footnotes accompanying the published articles, reveal that about half (46.2%) of them are employed by oil companies, a quarter are functioning in the educational field, and a quarter are distributed between consultants and employees of State agencies, State geological surveys, and Federal geological surveys. This spread of authorship safeguards the primary purpose of the *Bulletin*, namely, the dissemination of information useful to petroleum geologists, and also provides an adequate source for geologic material of more general application which may be of interest not only to our subscribers, but also to a wider circle of scientific readers.

What did our 1948 authors write about? Applying the four category classification used in last years editorial report, it develops that the subject matter of Volume 32 is distributed as follows.

Classes	*Percentage of Vol. 32*	*Percentage in Preceding 31 Vols.*	*Change*
1. Oil-field descriptions	11.5	11.5	0
2. Stratigraphy and paleontology	11.5	18.0	− 6.5
3. Regional geology and developments	55.2	38.0	+17.2
4. Miscellaneous	21.8	32.5	−10.7

The increasing expansion granted to the development papers published in the June issues of recent years adequately explains the rather remarkable 1948 increase of 17.2 per cent over the all-time average assigned to regional geology and developments. The ob-

served trend from the particular to the general, pointed out in last year's report, is still apparent in this result. Regaining the average level for oil-field descriptions, grist for the petroleum geologists' mental mill, is an attainment which, it is believed, is gratifying to officers, members, and readers alike.

Thirteen of the major papers in Volume 32 deal with geology and oil-field developments outside the United States. The growing importance of foreign-field articles is made manifest through the observation that, though representing only 14.9 per cent of the total number of titles printed, the number of pages devoted thereto (541) is 31.3 per cent of the space utilized by the 87 major contributions.

Close scrutiny of *Bulletin* matters during the past 2 years has made apparent to this observer that the preceding Association executives, editors, and authors have built up for the use of the membership an efficiently handled, well balanced, acceptably scholarly periodical which has made for itself a gratifyingly prominent place in twentieth-century geologic literature. To maintain that status is a major aim of Association activity. The urge for improvement, ever present with those charged with the direct responsibility of supervising the *Bulletin*, requires watchful curbing lest innovations be introduced without sufficient screening. This editor attempted none, having early satisfied himself that the maintenance of already established procedures guaranteed a product which, to him, seemed satisfactory. In retrospect, no reason for regretting that conclusion stands forth disquietingly.

Experience gained through manuscript contact with 200 or more authors may justify a few remarks concerning the form and nature of desirable *Bulletin* material from the editorial viewpoint.

No inflexible limits on *Bulletin* size have yet been imposed except those that are inherent in the industrial stringencies of the day, and in the availability of desirable manuscripts. It seems evident, however, that greatly enlarging the *Bulletin* beyond its present size is impractical. A seemingly irreducible minimum of about a quarter of the printed pages of the average issue is devoted to minor contributions and to Association affairs of one sort or another. The average major paper requires about twenty pages, including text and illustrations. Page space for five or more such papers is present in each issue. Now, while it is freely admitted that some papers require more space than twenty pages, it can hardly be denied that a few of twice that size would lose very little of lasting import if reduced to ten pages. The trend toward wordy generalization approaching monographic treatment is discernible in some offerings. Every individual in our ever-expanding membership probably has one good paper in mind. The time may, therefore, come when enough *Bulletin* space is not available for all those who have contrived contributions to knowledge. Writers of long papers should, if necessary, stand ready to share space with other contributors when that time does come. Meanwhile, reflection on the virtues of brevity may result in somewhat easing the paper shortage.

The quality of the illustrations submitted for publication is, in most cases, of a high order. A few drawings, however, are to be seen which neither adorn the *Bulletin* nor crown the author's brow with the laurel of distinction. Present-day drafting aids make possible, for all, the construction of drawings according to specifications set forth in the Association's pamphlet on preparation of manuscripts. Member pride in the appearance of his *Bulletin* should preclude the submittal of a makeshift drawing to illustrate a worthwhile text.

Priority rules in most schemes of nomenclature; it should also hold sway in the authorship of ideas. Most of our published papers are accompanied by adequate references; some have been criticized for carrying too lengthy bibliographies; some, alas, are all too brief. The policy of giving credit where credit is due should be the recognized obligation of every scientific writer; editors should not be held responsible for supplying missing references.

Cooperation of authors with Mr. Hull in galley proof reading has been gratifying, but

the lists of errata, though astonishingly small, still indicate that perfection in this detail has not been fully attained.

Now, lest the virtue of brevity be violated, I hasten to conclusion.

The two years that have so quickly passed have been fraught with many gratifying experiences. Association with the colleagues of two executive committees has been pleasant and inspiring. Relations with Mr. Hull and his staff have been friendly, business-like, and efficient. And, above all, the contacts maintained with the manuscript contributors, in whose hearts and minds rests the present and future welfare of our *Bulletin*, have yielded mental stimulation which could have been obtained in no other way. I can wish nothing finer for my distinguished successor, to whom I now turn over the office of editor, than that he experience pleasure in his new duties comparable with that which I have found in this period of service for the Association.

C. L. Moody, *editor*

Exhibit IV. Report (Minutes) of Business Committee

The annual business committee meeting was called to order in the Jefferson Hotel, St. Louis, Missouri, March 14, 1949, 9:15 A.M., by A. L. Selig, chairman.

1. *Roll call.*—Roll call by secretary J. V. Howell showed the following members and alternates present.

Chairman: A. L. Selig *Vice-chairman:* E. Floyd Miller *Secretary:* J. V. Howell

Executive committee: Paul Weaver, J. V. Howell, C. E. Dobbin, Roy M. Barnes, C. L. Moody

Members-at-large: C. W. Tomlinson, T. A. Link, A. H. Bell, Earl B. Noble, F. L. Aurin

Division	*Representative*	*Alternate*
Paleontology	R. Dana Russell	
	Henryk B. Stenzel (absent)	
District		
Amarillo	Wendell G. Sanford (absent)	Elisha A. Paschal
Appalachian	Fenton H. Finn (absent)	Sidney S. Galpin (absent)
Canada	C. S. Corbett	
Capital	W. G. Pierce (absent)	Watson H. Monroe
Corpus Christi	O. G. McClain (absent)	W. M. Chaddick, Jr.
Dallas	John W. Clark (absent)	R. E. Rettger
	Joseph M. Wilson	
East Oklahoma	Ralph A. Brant	
	Homer H. Charles (absent)	T. E. Weirich
	E. Floyd Miller	
	Sam H. Woods	
Fort Worth	Lynn K. Lee	J. B. Lovejoy
Great Lakes	J. A. Brown	
	E. E. Rehn	
Houston	R. B. Cantrell (absent)	
	H. L. Geis	
	C. L. Lake	
	R. B. Mitchell	
	H. C. Spoor, Jr.	
Michigan	Charles K. Clark (absent)	Richard A. Wolcott (absent)
New Mexico	Reuel L. Boss	
New York	Hollis D. Hedberg	
	Walter K. Link (absent)	
Pacific Coast	Gordon R. Bell	
	Frank B. Carter (absent)	C. W. Johnson
	T. J. Fitzgerald	
	W. S. W. Kew	
	L. W. Saunders	
	A. J. Solari	

District	*Representative*	*Alternate*
Rocky Mountain	A. F. Barrett (absent)	
	E. J. Boos (absent)	
	Kirk C. Forcade (absent)	
Shreveport	B. W. Blanpied (absent)	Claude N. Valerius
South America	Walter M. Chappell (absent)	Homer J. Smith
	J. M. Patterson (absent)	Verner Jones (absent)
Southeast Gulf	Henry N. Toler	
Southern Louisiana	J. W. Hoover (absent)	
South Permian Basin	Max David (absent)	George R. Putnam
	F. H. McGuigan	W. Dave Henderson
	V. C. Perini	
South Texas	George H. Coates	
	Robert Scott Mann	
Tyler	R. M. Trowbridge	
West Oklahoma	J. T. Richards	
	J. M. Westheimer	
Wichita	F. G. Holl (absent)	Frank A. Oyster
Wichita Falls	H. L. Rickard (absent)	James E. Wilson

2. *Minutes of previous meeting.*—It was moved, seconded, and carried that the reading of the minutes of the last meeting of the committee be dispensed with, as they were published in the June, 1948, *Bulletin.*

3. *Reading of reports of standing and special committees.*—The following reports were read.

1. American Commission on Stratigraphic Nomenclature, Wayne V. Jones, chairman
2. Committee for publication, George C. Grow, Jr., chairman
3. Research committee, John T. Rouse, chairman
4. Geologic names and correlations committee, Henry J. Morgan, chairman
5. Medal award committee, Paul Weaver, chairman
6. Distinguished lecture committee, Fred H. Moore, chairman
7. Committee on applications of geology, R. A. Stehr, chairman
8. Committee on statistics of exploratory drilling, Frederic H. Lahee, chairman
9. Committee on Boy Scouts literature, Frank Gouin, chairman
10. Committee on national responsibility of geologists, O. F. Kotick, chairman
11. Committee on preservation of cores and cuttings, Dollie Radler Hall, chairman

4. *Reports of standing and special committees.*—It was moved, seconded, and carried that the reports of the standing and special committees be accepted and referred to the annual meeting with the recommendation that they be not read but that they be published in the *Bulletin.*

5. *Committee on applications of geology.*—It was moved, seconded, and carried that sections and local societies be requested by the executive committee to appoint standing committees to cooperate in the preparation of geological road logs.

6. *Committee on Boy Scouts literature.*—It was moved, seconded, and carried that this committee be recommended to the executive committee for continuation for another year and that the incoming committee publish the manual on rocks which had been prepared, but that no Association funds be authorized for the special training courses at Philmont Camp in New Mexico.

7. *Committee on national responsibility of geologists.*—It was moved, seconded, and carried that this committee be recommended to the executive committee for continuation for another year.

8. *Committee on preservation of cores and cuttings.*—It was moved, seconded, and carried that this committee be recommended to the executive committee for continuation for another year with such support as the executive committee may deem necessary to carry out its program as heretofore outlined.

9. *South Texas Section.*—It was moved, seconded, and carried that the business committee recommend to the annual business meeting that the charter of the South Texas

Section be revoked and that the South Texas Geological Society be accepted as an affiliated society.

10. *Committee on statistics of exploratory drilling.*—It was moved, seconded, and carried that the business committee recommend to the annual business meeting that the following changes be made in section 12 of the By-laws: to omit the words "the methods used to locate," and to change the last sentence to read "This committee shall consist of 35 members, unless a different number is authorized by the executive committee."

11. *Method of election of officers.*—It was moved, seconded, and carried that no change in the method of election of officers be recommended for the consideration of the annual business meeting at this time.

12. *Amendment of Article III of Constitution, pertaining to membership, and changes of appropriate By-laws.*—It was moved, seconded, and carried that the following resolution be adopted and the substitutions and changes in the Constitution and By-laws be recommended to the Association in annual business meeting for favorable action.

Resolved: That in order better to preserve the geological identity of the American Association of Petroleum Geologists, the Constitution and By-laws of the Association be hereby amended to read as they appear below, provided, however, that:

Constitutional changes herein described shall not be retroactive and will not affect the status of any member or associate duly elected before the effective date of these amendments;

Changes in the By-laws affecting the amount and payment of annual dues shall not apply to dues for the calendar year 1949, except for new members elected subsequent to the adoption of these amendments;

Associates elected before the adoption of these changes, who are privileged, under the present regulations, to pay annual dues of less than $10, may, if they have the necessary geological qualifications, transfer to junior membership, and thereafter enjoy all the privileges of this classification, including the provision for annual dues of $8 for a period of three years from the original date of election to membership in the Association.

ARTICLE III. MEMBERSHIP

Members

SECTION 1. Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology is eligible to active membership, provided he is a graduate of an institution of collegiate standing in which institution he has done his major work in geology and in addition has had the equivalent of three years' experience in petroleum geology or in the applications of geology to problems involving exploration, development, research, or other phases of petroleum technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in geology in recognized institutions, whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.

Junior Members

SECTION 3. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to junior membership, provided at the time of his application for membership he shall be engaged in geological studies or teaching in an institution of collegiate or university standing, or shall be engaged in petroleum exploration.

Junior members shall be known as juniors.

Junior members shall enjoy all the privileges of membership in the Association save that they shall not hold office, sign application for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise. The executive committee may advance to active membership those junior members who have fulfilled the requirements for active membership.

Associate Members

SECTION 4. Any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences closely related to or generally associated with petroleum geology, petroleum exploration, or petroleum exploitation, who does not have the full geological requirements

for active membership but has the equivalent of three years' experience in the application of his science to the study of petroleum geology shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in some branch of petroleum exploration or in investigations in the broader subject of petroleum geology or exploitation.

Associate members shall be known as associates.

Associate members shall enjoy all the privileges of membership in the Association save that they shall not hold office, sign application for membership, or vote.

The executive committee may transfer to active membership upon application those associates who have, subsequent to election, fulfilled the requirements for active membership.

Election to Membership

SECTION 5. The wording of this paragraph would be exactly as the present Section 4, except for the following two changes: (1) The first line will be changed to read "Every candidate for admission as a member, junior member, or associate shall submit," *etc.*; (2) Lines 9 and 10, following the wording "why the applicant should not be admitted," shall be changed to read "he shall be deemed eligible to active, junior, or associate membership as the case may be, and shall be notified of his election."

SECTION 6. This will be the present Section 5 without change.

SECTION 7. This will be the present Section 6 without change.

SECTION 8. This will be the present Section 7 with the word "junior" inserted as follows: "Each member, junior, and associate," *etc.*

SECTION 9. This will be the present Section 8 except that the word "junior" will be inserted after the word "member" so that it will read: "Any member, junior, or associate who, after due investigation," *etc.*

BY-LAWS

ARTICLE I. DUES

SECTION 2. The annual dues of members and associates shall be $10. The annual dues of juniors for not to exceed three years after election shall be $8; thereafter the annual dues for such juniors shall be $10. The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member, junior, and associate before December 1st of each year stating the amount of the annual dues and the penalty and conditions for default in payment. Members, juniors, and associates who fail to pay their annual dues by January 1st shall not receive copies of the January *Bulletin* or succeeding *Bulletins*, nor shall they be privileged to buy Association special publications at prices made to the membership, until such arrears are met.

Paragraph 2 of Section 2 will be the same, except that the words "juniors and associates" will be inserted in line 3, following the word "members" so that this line will read "or waive annual dues to members, juniors, or associates serving in the armed forces," *etc.*

ARTICLE II. RESIGNATION—SUSPENSION—EXPULSION

At places in Sections 1, 2, 3, 4, and 5 of Article II the word "junior" shall be inserted after the word "member" in order that in each case the wording will be: "members, juniors, or associates." These changes apply to Section 1, line 1; Section 2, lines 1, 3, and 5; Section 3, line 1; Section 4, lines 1, 4, 5, 8, and 11; Section 5, line 7. Sections 6, 7, 8, and 9, no change.

ARTICLE III. PUBLICATIONS

SECTION 2. Insert "junior" after the word "member" in line 1.

A. L. SELIG, *chairman* E. FLOYD MILLER, *vice-chairman* J. V. HOWELL, *secretary*

EXHIBIT V. REPORT OF REPRESENTATIVE OF DIVISION OF GEOLOGY AND GEOGRAPHY OF NATIONAL RESEARCH COUNCIL FOR YEAR 1948

The Division of Geology and Geography of the National Research Council serves as a clearing house through which geologists working in diverse fields may be brought together, and as a liaison between geologists and workers in other sciences. During the past year, the Division was under the chairmanship of Arthur Bevan of the Illinois Geological Survey.

An outstanding event of the year 1948 was the activation of the American Geological Institute as an affiliate of the National Research Council. The first annual meeting was held November 15 and 16, 1948, and was attended by delegates of eleven geological societies. A. I. Levorsen was elected president, W. B. Heroy vice-president, and E. T. Ingerson secretary-treasurer. Standing committees of the Institute were set up to deal with such fields as education, personnel, publications, and public and Government rela-

tions. The Institute will considerably broaden the base of usefulness of the National Research Council as a clearing house for geologists. The Division of Geology and Geography will retain its functions as a coordinator of geologic research.

During the year, representation on the Division of Geology and Geography was increased by the addition of five new member societies: the American Society for Professional Geographers, the Seismological Society of America, the Society of Economic Paleontologists and Mineralogists, the Society of Exploration Geophysicists, and the Society of Vertebrate Paleontologists. Each of the new member societies has appointed a representative who serves as a member of the Division.

The Division continued its study of geological education and personnel. The "Committee on geologic personnel" (W. B. Heroy, chairman) continued its work in this field. The "Committee on advisory pamphlet for geology students" (C. H. Behre, chairman) prepared a short manuscript on "Careers in Geology" which was published in the October, 1948, issue of the *Engineering and Mining Journal*. An edition of 5,000 reprints of the article was printed for distribution to students and other interested persons.

Committees of the Division whose work is of particular interest to petroleum geologists include:

The "Committee on stratigraphy" (C. O. Dunbar, chairman) continued its work of preparation and publication of correlation charts of the geologic systems. Charts in progress include one on the Ordovician and one on the Permian of the United States, one on the Jurassic of the southwestern United States, and three on the Cretaceous (far western United States, western interior, and Canada).

The "Committee on symposium on sedimentation" (P. D. Trask, chairman) worked on the "Symposium on practical aspects of sedimentation." A sub-committee on the rock color chart (E. N. Goddard, chairman) arranged for publication and sale of this chart. The chart was prepared with the financial assistance of the American Association of Petroleum Geologists, the Geological Society of America, and the Society of Economic Geologists, and with the cooperation of the United States Geological Survey and the Association of American State Geologists. The chart is sold by the National Research Council at $5.50 per copy.

Also of interest in the field of sedimentation is the newly organized "Committee on study of aeolian deposits in the United States and Canada" (James Thorp and H. T. U. Smith, co-chairmen).

The "Committee on treatise on marine ecology and paleoecology" (H. S. Ladd, chairman) continued its work on the treatise. A report for the year 1947–1948 is ready for publication and contains the chapters of the treatise that have so far been prepared.

The "Committee on stratigraphic paleontology" (R. C. Moore, chairman) devoted the year to compilation of data on present status of paleontological zonation in the different geologic systems.

The "Committee on deformation of the Ross shelf ice" (W. H. Bucher, chairman) reports completion of a paper summarizing the work accomplished. The "Committee on experimental deformation of rocks" (E. B. Knopf, chairman) is cooperating with the department of geophysics, School of Mineral Production, University of Utah, in research on the fabric of marble. The results of both committees will have many interesting applications in the field of tectonics.

PHILIP B. KING, *chairman*

EXHIBIT VI. REPORT OF REPRESENTATIVES ON AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE

The annual meeting of the Commission was held in New York City on November 12, 1948. The Association was represented by Commissioners Monroe G. Cheney and Wayne V. Jones, and by C. W. Tomlinson, alternate for Commissioner John G. Bartram. Much

of the time of this meeting was occupied in working out and adopting detailed procedure for formal and final consideration of the problems pending before the Commission.

The problems now pending are: (1) "Nature and Classes of Stratigraphic Units" which proposes a three-fold classification consisting of time units, time-rock units, and rock units, (2) "Naming of Subsurface Stratigraphic Units" which proposes to bring subsurface units more nearly into equal status with surface units and at the same time to provide more precise rules for naming such units, and (3) "Definition and Adoption of the Terms Stage and Age" which proposes the addition of these terms to the Stratigraphic Code in order to conform American usage to that of the International Geological Congress. Each of the proposals appears fundamentally sound, but some details are controversial and, as a result, action by the Commission has been delayed. The problem on "Naming of Subsurface Units" has just been mailed to the Commissioners for their vote to approve or reject. The opinion on the problem on "Nature and Classes of Stratigraphic Units" is on the formative stage and probably will be ready to be voted upon in the near future.

The next meeting of the Commission will be in El Paso, Texas, in November, 1949. Comments or suggestions as to matters before the Commission or which possibly should be considered by the Commission are always welcome and should be addressed to the chairman of the Commission, Raymond C. Moore, University of Kansas, Lawrence, Kansas.

WAYNE V. JONES, *chairman*

EXHIBIT VII. REPORT OF COMMITTEE FOR PUBLICATION

The committee for publication has again this year assumed responsibility for securing authors for the annual development papers which will appear in the June *Bulletin*. The coverage of these papers has gradually expanded so that now practically all major oil and gas developments in the entire world, as well as those in the United States, are covered by A.A.P.G. authors. The usefulness of these reports is shown by the fact that the requests for extra copies of the June *Bulletin* far exceed those for other issues. A.A.P.G. authors attempt to emphasize the geological significance of new discoveries and developments. Continued efforts are being made to unify as far as possible the scope of coverage and method of presentation, so that the publication of all development papers may remain in one *Bulletin*.

Excellent material for other issues of the *Bulletin* is still being amply supplied by the membership at large; hence, it has not been necessary for the committee to make a concerted effort in this respect.

The committee expresses appreciation to the authors who have published material in the *Bulletin*, and the chairman is particularly appreciative of the fine cooperation by the committee as a whole.

GEO. C. GROW, JR., *chairman*

EXHIBIT VIII. REPORT OF RESEARCH COMMITTEE

The annual meeting of the research committee was held in St. Louis on the evening of March 13 and the morning of March 14, 1949, and was attended by a majority of the committee members. There follows a summary of the activities for the past year.

1. *Symposium.*—Last July the members of the committee were asked to submit a subject and speakers for a symposium to be presented at the annual meeting in St. Louis. As a result of this poll of committee members the subject "Control of Oil and Gas Accumulation by Sedimentary Facies" was selected and seven papers were obtained for this symposium. The titles and authors of these papers appear in the program of the annual meeting. Some of the papers were prepared by individuals and others by research committees of the local societies.

2. *Project 11, "Experimental Tectonics."*—L. L. Nettleton was asked to continue to

serve as chairman of the subcommittee on Project 11 and M. King Hubbert was appointed to serve with Nettleton to review its placement at some institution. As a result of their work and on their recommendations, the project has been placed at the Texas Engineering Experiment Station and the Department of Geology, A. & M. College, College Station, Texas. Professor S. A. Lynch is the project director and the studies are being carried on by Professors A. N. McDowell and T. J. Parker, both members of the faculty of the Geology Department at Texas A. & M. The Texas Engineering Experiment Station has appropriated approximately $6,500 for work on this project and this will finance it to September 1, 1949. The following progress report, prepared by McDowell and Parker, has been received from S. A. Lynch.

The project at Texas A & M was activated on February 1, 1949, with the assignment of two geology department staff members to half-time duties on this tectonics research program. A work room with office space for these men has been established exclusively for the project. Work tables have been set up and working materials are being assembled. The part-time services of a geology student have been made available to provide additional manpower for the initial phases.

Preliminary model studies in the broad field of salt-dome tectonics are under way. The phase under current investigation concerns the structural deformations of the material simulating the sediments by various intrusives with particular observation of fault patterns produced. Also, preliminary experiments are being conducted with clays and other substances which will flow plastically.

It has been found necessary to devote considerable time and effort to the perfecting of the required operational techniques and to the familiarization of the personnel with the physical properties of the media to be used.

In addition to the physical progress mentioned above, detailed studies of existing literature are still in progress and will be continued as new phases of the project are entered.

Nettleton and Hubbert have agreed to be of any possible assistance in an advisory capacity with respect to prosecution of the project and, in addition, to devote time individually in an advisory and consulting capacity.

3. *Project 5, "Recent and Near-Recent Sediments."*—The American Petroleum Institute is still actively considering the sponsorship of Project 5. As yet the subcommittee of the A.P.I. Advisory Committee on Fundamental Research has not completed its investigation but it is hoped that this subcommittee will be able to present a definite recommendation to the A.P.I. Advisory Committee on Fundamental Research by the middle of this year.

4. *Subcommittee on Reservoir Conditions.*—Under the chairmanship of Parke A. Dickey this subcommittee has nearly completed a "Glossary of Terms Used in Describing Geological Properties of Petroleum Reservoirs." This group hopes to be able to submit this for publication in the near future.

5. *Directory of Geology Departments of Educational Institutions in the United States and Canada.*—This is completed and is ready to be submitted for publication. The directory gives the name and location of the institution; individual faculty members with their rank, highest degree, where and when the degree was received; geology courses offered; and requirements for a major in geology.

6. *Current Geologic Research in Universities.*—The research committee feels that an appreciable amount of research work is being conducted in the universities, much of which never comes to the attention of members of the A.A.P.G. John T. Lonsdale has sent a questionnaire to seventy-five universities and replies have been received from forty-five. The committee is now considering methods by which this research can be brought to the attention of the members of the A.A.P.G.

7. *Cooperation with Universities in Research Related to Petroleum Geology.*—Professor Alton Wade and associates at Miami University are making petrographic studies of carbonate rocks. Future plans call for more active cooperation with universities.

The chairman of the research committee would like to take this opportunity to thank the members of the research committee, the members of the A.A.P.G., and the executive committee for their enthusiastic support of our work during the past year.

JOHN T. ROUSE, *chairman*

Exhibit IX. Report of Geologic Names and Correlations Committee

As stated previously, "it is the desire and aim of the geologic names and correlations committee to enlist the aid of the affiliated societies in large-scale cooperative projects having to do with the nomenclature and correlation of formations located in the areas of interest to them."

The method used in implementing this policy was to divide the area of interest into geographical and geological districts with the committee having representation in each local society. For details of the organization, you are referred to the article "Functions and Organization of Geologic Names and Correlations Committee" in the *Bulletin* of the A.A.P.G., Vol. 30, No. 12 (December, 1946).

The first project set for the committee as a whole was the consideration of the names and correlations of the outcrop and subsurface formations in the areas of interest to the profession. It was planned that this study would lead to work which would result in the eventual construction of numerous annotated correlation charts, accompanied by detailed geologic cross sections.

Much very detailed and accurate subsurface correlation work is being done all over the oil areas of the United States by local societies and individuals which never becomes available to the profession as a whole. The present over-all aim of the committee work to-day is to get this information worked up in useable and coordinated form and arrange for its publication by the Association.

GENERAL COMMENTS

Progress of work.—It was felt from the beginning that, if one or more projects of this nature could be worked up and published, the task of interesting other local societies and individuals in taking an active part in the program would be made much easier. Two projects, one located along the Gulf Coast and involving Mesozoic horizons, and the other located in the Eastern Interior and Appalachian Basin regions and involving Paleozoic horizons, were chosen for the most intensive effort.

Both of these projects are well under way and it is believed that they will furnish enough material for an initial publication.

The Cenozoic subcommittee is working on a similar project along the Gulf Coast which, however, is not as far advanced as the two previously mentioned.

The principal effort in the other regions has been directed toward keeping the organization alive, doing missionary work, and toward encouraging the societies in working on stratigraphic problems.

Difficulties.—The difficulties encountered in pushing the program through were the usual ones attending committee work and might be summarized as follows: (1) trouble in finding the right men for the key positions; (2) resignations of committee workers—almost always due to transfer or change of status; (3) lack of continuity of work, due both to these resignations and to short-term (usually one year) committee appointments by the local societies; (4) poor liaison between the district chairman and societies in his district.

One of the most encouraging things about the work as a whole has been the generally cooperative attitude of the societies and individual members. Most of the difficulties encountered have been due primarily to lack of contact and effort on the part of the district chairmen, rather than lack of cooperation on the part of the societies.

Remedies.—It is planned to encourage, in every way possible, more personal contact between the district chairmen and societies in his district. The societies will be asked to appoint standing committees whose terms will last two or three years rather than temporary short-term committees.

STATUS OF SUBCOMMITTEE ACTIVITIES

Cenozoic subcommittee.—Robert T. White of Los Angeles has been appointed to the main committee recently, as chairman of the Cenozoic district committee for the Pacific Coast, in place of Rollin Eckis, resigned. There is one vacancy for the Rocky Mountains and Great Plains district of the Cenozoic, created by the resignation of Harry A. Tourtelot. Mr. Tourtelot was transferred. A successor has not been chosen as yet.

The Eastern and Western Gulf Coast districts are actively engaged in a cooperative project which will involve: (1) the construction of two main strike sections and several dip sections in the Gulf Coast area, extending from Florida to the Rio Grande; (2) the construction of correlation charts; (3) the preparation of a certain amount of accompanying text.

On the Atlantic Coast, no set project directly concerned with committee activities is under way at the present time. However, member H. G. Richards is in charge of a Philadelphia Academy of Science project which he instigated and which the committee aided materially in getting under way. This work, so far, has resulted in the furnishing to member companies of four quarterly reports on stratigraphic developments disclosed by drilling of all types along the Atlantic Coast.

Mesozoic subcommittee.—The Pacific Coast district of this subcommittee has never been activated, largely because of the lack of interest in beds of this age. It has not been abandoned, however, and doubtless some useful work for this district will suggest itself at some future time.

C. I. Alexander, due to transfer, has resigned from the important Gulf Coast district committee. T. H. Philpott, of the Carter Oil Company at Shreveport, has been appointed in his place.

The Gulf Coast district has been working for some time on a project involving the construction of a strike section. Chairman Thomas advises that four of the five parts of this section are completed and that he is bringing them for display at the St. Louis meeting.

In the Rocky Mountains and Great Plains district, chairman Heaton does not have any set projects under way to be credited wholly to the committee, but he has interested himself in, and furnished valuable assistance to, three societies in his district, that have stratigraphic projects under way.

On the Atlantic Coast, chairman Richards' activities have already been mentioned under the Cenozoic discussion.

Paleozoic subcommittee.—Two of the districts in the area of concern, i.e., the Appalachian and the Eastern Interior districts, are actively engaged in the construction of dip and strike sections. Chairman Workman advises that the section extending from Michigan to Mississippi, in four parts, will be on display at the St. Louis meeting.

In the three other districts of this large subcommittee, i.e., the Southwestern United States, the Mid-Continent, and the Rocky Mountains and Great Plains, no projects that can be credited wholly to the committee are under way. However, numerous individual society projects that committee members have interested themselves in promoting are under way. When finished, these studies will furnish valuable data for future committee work.

Advisory and special projects committee.—Chairman Cheney has recently submitted to his committee a further development of an idea which was submitted to the executive committee in March of last year and referred by them to the main committee on geologic names and correlations. I feel that his plan, which involves the compiling of "a summary of revisions of stratigraphic names and correlations of interest to petroleum geologists" is most intriguing when considered as a source of projects which could well be undertaken by units of the geologic names and correlations committee.

This proposal is now being circulated by Cheney among the members of his subcommittee, for comment.

HENRY J. MORGAN, JR., *chairman*

EXHIBIT X. REPORT OF COMMITTEE ON APPLICATIONS OF GEOLOGY

The *Directory of Films and Slides* was completed in the early part of 1948 and 500 copies were printed. As of March 1, 288 copies had been distributed to numerous societies, institutions, and geological departments of approximately 200 colleges and universities. Requests are still coming in.

Our committee has devoted considerable time and enthusiastic discussion to a new project—geologic highway logs for the travelling public. Since this is a very ambitious project and will require the cooperation of all A.A.P.G. affiliated societies, no definite plans have yet been formulated. During the coming year definite recommendations on procedure will be made.

The committee recommends that standing committees on applications of geology be selected to represent each of the various sections of the A.A.P.G. We believe it is essential to have the cooperation of active and alert local society committees in order to accomplish our objectives.

Several new projects, including "Geological publicity" and "Water resources" have been discussed. They will be pursued further during the coming year.

R. A. STEHR, *chairman*

EXHIBIT XI. REPORT OF MEDAL AWARD COMMITTEE

As chairman of the medal award committee, I wish to report to the business committee that the medal award committee has selected for the President's Award, Sherman A. Wengerd for the paper entitled "Fernvale and Viola Limestones of South-Central Oklahoma," as the paper which, in the opinion of the committee, was the outstanding paper by an author under 35 years of age, published in the *Bulletin* of the Association during the year 1948.

The award to Wengerd will be made at the joint meeting tomorrow (Tuesday) morning.

PAUL WEAVER, *chairman*

EXHIBIT XII. REPORT OF COMMITTEE ON STATISTICS OF EXPLORATORY DRILLING

The committee on statistics of exploratory drilling functioned efficiently in compiling data on the exploratory wells drilled in 1948 in spite of the fact that there were more than 8,000 such wells, the largest number ever drilled in the United States in any one year. However, in some districts the committeemen were responsible for so many wells, and the burden of collecting and recording information was so great that the chairman believed that such districts should be divided, and toward this end he recommended to the executive committee that they modify the by-law pertaining to the committee on statistics of exploratory drilling so that the authorized number of its members will be raised from 24 to 35. (See By-laws, Art. VI, Sec. 12.) This action has now been taken and the change approved by the executive committee.

Another question was brought to the attention of the executive committee, namely, whether or not members of the main committee on statistics of exploratory drilling might be persons who are not members of the Association. On this question the executive committee judged that members of the main committee should always be members (not necessarily full members) of the Association, but that this rule need not strictly apply to all members of the sub-committees of the C.S.E.D.

In compiling the data for 1948 the adopted classification was used as it has been in the past several years, without modification. It is found to be the simplest complete analysis

of all types of exploratory wells. On the other hand, by majority vote of the committee, in order to eliminate any work not judged to be essential, certain kinds of information were omitted from the record except in the case of new-field wildcats (rank wildcats). Such were data on financing and on the basis of location of wells. For further easing of the task of compiling statistics in the future, we again urge current recording, either weekly or monthly. This would mean lessening the burden for the committeemen after the close of the year, it would enable these men to transmit their figures to the chairman more promptly, and it would facilitate his work in summarizing the vast bulk of information which he receives and on which he must base his annual report.

During the year the chairman had opportunity to visit Mexico City and Calgary, and in each place, to talk to the local geologists on the subject of classifying and reporting on exploratory wells. He is happy to state that from both Mexico and Canada, this year for the first time, he received statistics on the 1948 exploratory drilling, and that these statistics have been included in the annual report to be published in the *Bulletin* next June.

F. H. LAHEE, *chairman*

EXHIBIT XIII. REPORT OF DISTINGUISHED LECTURE COMMITTEE, 1948–1949 SEASON

The distinguished lecture committee wishes to express its appreciation to the following speakers who have made possible the completion of another successful year.

Gerald FitzGerald	Washington, D. C.
J. M. Harrison	Ottawa, Canada
George G. Simpson	New York, N. Y.
Walter H. Bucher	New York, N. Y.
A. I. Levorsen	Stanford, California
H. D. Thomas	Laramie, Wyoming
Francis P. Shepard	La Jolla, California

These seven men have presented a wide variety of scientific data of interest to the geological societies. We feel that these speakers have continued to carry out the purpose of this committee, which is to keep the men in the field abreast with advancing thought in geology.

During this past year we have sponsored seven speakers who have presented 110 lectures before 40 different geological groups. This compares with 107 lectures before 39 different groups during the previous year.

Interest in the committee work continues at the same high level as in the past. The results of a recent questionnaire to the various societies indicate that a big majority are in favor of continuing the work of this committee along the same lines it has been carried on in the past, and they feel that it has an important part in the life of the local societies.

This work has been carried on through use of a $1,500 revolving fund from the Association, and it is recommended that it remain the same for another year.

The committee wishes to thank the officers of the local societies who have cooperated so closely in making this program possible.

FRED H. MOORE, *chairman*

EXHIBIT XIV. REPORT OF COMMITTEE ON BOY SCOUTS LITERATURE

Your committee is at last making some definite progress. R. C. Spivey and Carl Branson, representing both this committee and the West Texas Geological Society, have written the proposed Geology Merit Badge pamphlet. Max W. Ball and Don Carroll are editing the pamphlet. When finished it will embody the suggestions of all members of this committee plus many other interested members of the Association. It is planned to test it in the field this summer both at Philmont and at other Boy Scout camps in order that we are sure we have something that will really be interesting to boys before we submit it to National Headquarters of the Boy Scouts of America.

This phase of our work is intended to bring into the Boy Scout program a science which

is a "natural" when considering the broader aspects of the whole Scouting program. Since one chief object of the entire Merit Badge program in Scouting is aimed at helping the young man decide what he wants to do in life, we do not know of a better method of teaching the youth of the land of the elementary principles of the science of geology. Later, when the Geology Merit Badge pamphlet has been approved and is in general circulation and the young man has secured his Merit Badge in Geology, if he finds he is interested in going further he can take the intensive two-week course in geology exploration at the Philmont Scout Ranch at Cimarron, New Mexico, and find out pretty surely whether he really does want to study geology in college or not. From our angle we know of no better method of finding young men who might become "naturals" in the science of geology.

Our mid-year report contained the result of the geology exploration program at Philmont last summer. This summer we will have four periods of two weeks each during the months of July and August. There will be a different geologist instructor for each of the four groups under the supervision of Professor Ray Six of Oklahoma A & M, who will teach one of the four groups. There will be 20 Senior Scouts (high-school boys) in each group plus two adult leaders in addition to the instructor. Boy Scout councils all over the land are selecting top-rank Senior Scouts who are interested in science. The young men can make individual applications as there are no quotas whatsoever. This is something that is not generally known by Scout officials for it is different from past procedure for Senior Scouts going to Philmont. In the past each Council had definite quotas. This is mentioned for it is just possible there will still be places open when this report is published. Application blanks can be secured by wiring or writing direct to Philmont. By next summer we hope competition is so keen that eighty councils will feel themselves fortunate to be able to send their one top Senior Scout to the geology exploration program at Philmont.

Scout executives take special training at Philmont in the spring and fall before and after the summer training for Senior Scouts. While there they learn of the various innovations in Scouting. From this standpoint alone we feel the geology program there is one means of disseminating the ideas of geology throughout the Scout world. In addition to that, since the Philmont Scout Ranch is directly under the New York office of the Boy Scouts of America, there is no question but that the top executives know of our program and its results.

We have had an extremely fine response from experienced geologists offering to volunteer their services for two-week periods in geology exploration as instructors at Philmont for this summer. We are also getting fine support from many geologists in helping Scout executives select and screen Senior Scouts for the courses. We are very much indebted to the authorities at Philmont for their whole-hearted support. They suggested the idea of trying out our proposed Geology Merit Badge pamphlet in the field there this summer. We have a feeling this will be the year when the chief purpose of this committee will be accomplished.

FRANK GOUIN, *chairman*

EXHIBIT XV. REPORT OF COMMITTEE ON NATIONAL RESPONSIBILITY OF GEOLOGISTS

The committee on national responsibility of geologists was formed in July, 1948, at the request of the president. Membership was selected so as to cover the whole of the United States. Members from Europe and the Far East were included with a view toward broadening the thinking of the committee. The scope of the committee's activity was not designated beyond an implied need for plans and actions in regard to (1) the military draft of geologists from an already inadequate supply, and (2) liaison between the organized geological societies and the Military Services. Since its inception, the committee has struggled with the problem of clarifying the scope of activity implied by its name. The above stated objectives in relation to the draft and to planning with the Military Services seemed clear enough and appropriate actions were taken. These actions will be brought out later in this report. Other implied responsibilities have been very difficult to define.

The term "national" connotes responsibility to the Nation, primarily to the Federal Government, its departments and other subdivisions. Yet in a broader sense, it seems that it should apply to State and Local Governments and to the people as a whole. We recognize these responsibilities as individual geologists, and as an organization of geologists.

Our national responsibility as individual geologists is identical with those of all other individual citizens—to promote the general welfare, provide for the common defense, and to secure the blessings of liberty to ourselves and to our posterity. We take pride in our profession and have organized into this group to accomplish certain desired objectives specified in our constitution through the greater strength of the group.

Our national responsibility as an organization of petroleum geologists is to examine closely into our obligations to the Nation, including the governmental structure, the educational structure, and the industrial structure as geology pertains to them and to suggest or effect needed improvements where such action appears desirable. Looking at the organizational structure of this country we find such agencies as the United States Geological Survey and the Bureau of Mines to serve the people through the Federal Government; offices of State geologists to serve the people through the State Governments; departments of geology and geophysics within our colleges and universities to serve the demands of the people for education and research; many local geological societies, groups and committees to serve the local needs and interests; and a vast, well organized petroleum industry to meet special demands of a vigorous, growing Nation. We must conclude that all these organizations are adequate to fill the need unless a deficiency can be demonstrated and a concrete supplement or remedy recommended.

What are some of these deficiencies which we, as an organization, can understand and correct? One is within the Federal Government and corrective steps are being taken.

Geologists have long recognized the inadequacy of mutual planning between the Military Services and organized geology for the effective application of geology and the functioning of geologists in the services. The Army indicated a recognition of this need when it perpetuated the Military Geology Unit in the United States Geological Survey under the operational control of the Chief of Engineers. In addition to this, the Department of the Army is calling to 30 days' active duty an Engineer Reserve officer, recommended by this committee, to study the subject and report to the Chief of Engineers. It is our thought that one result of this study will be the establishment by the Army of a permanent, recognized board of civilian geologists whose mission will be to plan and advise with the Army during peace on the geological functions and requirements of the services during war.

Another concrete step is being attempted through the American Geological Institute by requesting the Secretary of Defense to recognize the need for deliberate liaison between the American Geological Institute and a specified military agency selected by the Secretary. In order to be prepared for intelligent planning, this committee is now circularizing A.A.P.G. members who served in the armed forces during World War II. The type of information requested has been coordinated with the Department of the Army and is essential to our activities. The support of all members is requested.

There may be deficiencies within the State geological offices and the science departments of our colleges and universities, but until we can demonstrate their existence, the most we can do is to urge the executives thereof to examine closely into their own public responsibilities and determine themselves whether weaknesses exist and, if so, to take corrective action.

Two important national responsibilities of the A.A.P.G. come under the cognizance of other committees. The first pertains to general education of the public in things geological, and the second has to do with providing an annual estimate of our undiscovered reserves.

Most of us seem to agree that we have a responsibility to the Nation of explaining to the public in general what the science of geology is all about. Most persons exhibit a great interest in the more spectacular geologic phenomena such as earthquakes, volcanoes,

blow-outs of gas and oil wells, tidal waves, the majestic scenery of certain caves, canyons, and badlands, the fantastic evolution of the Mesozoic reptiles, glaciation, submarine canyons, precious stones, impacts of meteors with the earth, *et cetera.*

These spectacular forms of geology provide an adequate vehicle to weave in the equally interesting but quieter phases of historical geology, an explanation of the scope of geological activities, the rugged physical requirements of field geologists (as contrasted to the chair-borne type), the substantial amount of time required to unravel the mysteries of Old Mother Earth and her fleeting revelations, and the many values which geology can contribute to a greater fullness in the lives of all. This educational responsibility, however, comes within the established scope of the committee on applications of geology. My committee can only point out the need for pushing this work forward.

Attention to another national responsibility has been invited by A. I. Levorsen at the Denver meeting in April, 1948, and published in the last July issue of the *Bulletin*—to assure an ample supply of petroleum, available at all times and for any emergency, by keeping the wildcatter going through geological vigor, particularly in the partially explored regions, and by providing the public with an authoritative, objective annual statement of our undiscovered petroleum resources. It is understood that this important function is being handled by a special committee under the leadership of E. L. DeGolyer. Conceivably, when the American Geological Institute becomes adequately organized, this function can properly be expanded to include all minerals essential to the national security.

The problem of keeping the wildcatter going is of vital importance to our national security and one which challenges the imagination of our best minds. Geological vigor is a requirement every geologist in industry, from the director to the embryo, must meet from a personal standpoint. But all the vigor in the world is stymied when production is cut back and prices drop. There must be a financial relief of some sort for finding and holding new production in a quiescent status until the rarefaction wave rises to the compression stage. The question of how this relief may be obtained merits our full attention and ingenuity.

This committee concludes:

1. That the activities of the committee concerning national responsibilities of geologists more appropriately pertain to the A.A.P.G. than to its component individuals, and the committee name should be changed accordingly.

2. That the committee should continue in existence for at least another year.

3. That the committee's activity relating to the Military Services has been the only clear-cut national responsibility observed to date which is not being handled by other committees. We undoubtedly have other responsibilities of national scope, but they are not yet sufficiently well defined to indicate the direction or degree of committee action.

This committee recommends:

1. That this committee be continued under the name of Committee on Responsibilities of the A.A.P.G.

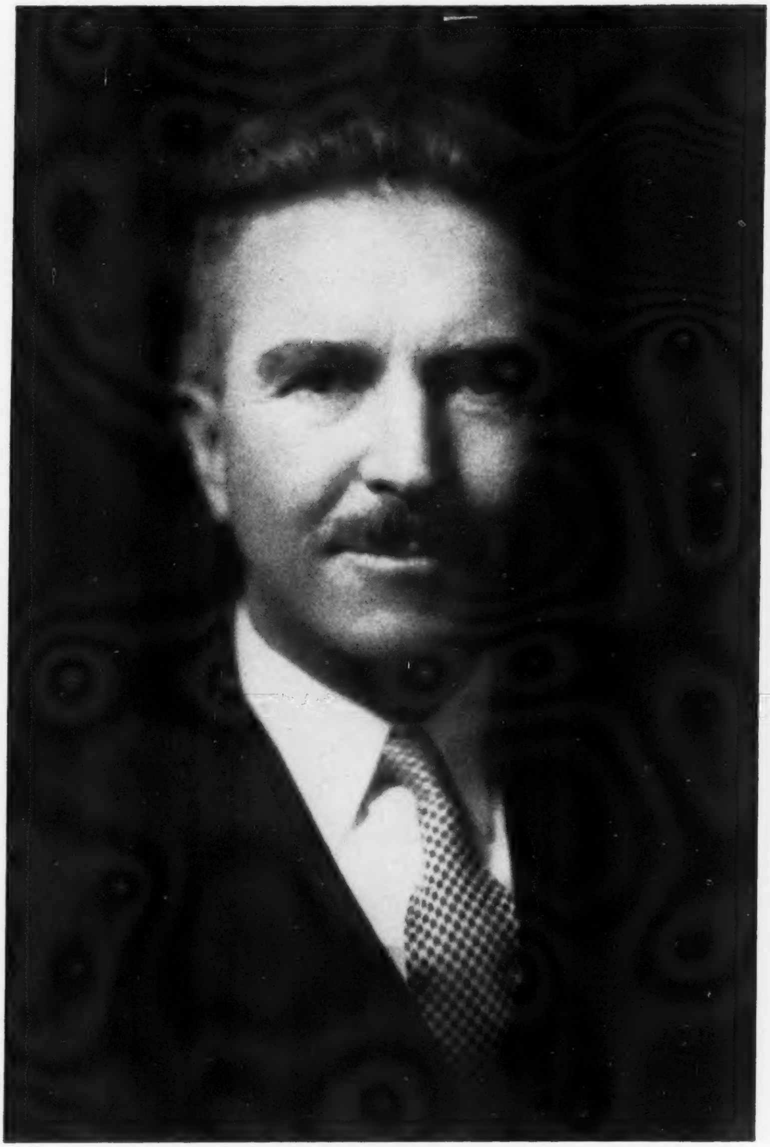
2. That its objectives will be to:

a. Plan and advise with the Military Services for the effective application of geology and the efficient functioning of geologists within the Military Services.

b. Take under consideration such other contributions to the national benefit for which the A.A.P.G. is morally or otherwise responsible and which are not being effectively accomplished by other committees or organizations.

3. That the services of this committee be offered to the American Geological Institute to function for that organization with regard to the Military Services as outlined in 2a above, until such time as an appropriate committee of the A.G.I. can be organized.

O. F. Kotick, *chairman*



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Gulf Oil Corporation, New York, N. Y.

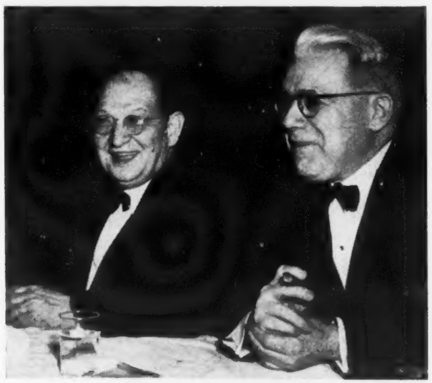
President Weaver, vice-president Roy M. Barnes, Francis M. Van Tuyl, honorary member.

G. Clark Gester receiving honorary membership certificate from president Paul Weaver.

President Weaver congratulating Sherman A. Wengerd, recipient of President's Award. Editor Clarence L. Moody in center.

Oil-field equipment exhibits, opposite entrance to Gold Room, Jefferson Hotel. Forty-nine equipment exhibitions were on Mezzanine. Fourteen geological societies and surveys were on second floor.

Field and laboratory equipment, east side of Mezzanine, Jefferson Hotel.



Enjoying dinner-dance and floor show:
Paul Weaver and J. V. Howell.

Accommodating Buzz Taylor, photographer, at annual dinner-dance. Seated (left to right): L. L. Nettleton, C. W. Tomlinson. Standing: C. E. Dobbin, Mrs. J. V. Howell and J. V.

Registration on Mezzanine. Estimated attendance, 3,500; largest A.A.P.G.-S.E.P.M.-S.E.G. joint annual meeting. St. Louis Convention and Publicity Bureau girls rendered complimentary service and St. Louis Public Service Company (Gray Line Tours) furnished free information.

At height of registration, five girls took registration cards, one-dollar registration fees, typed name plates for badges, and gave out programs; another girl sold tickets for A.A.P.G. field trip to Cape Girardeau and for S.E.G. laboratory trips; another girl attended the information booth. House phone, outside-line phone, loud-speaker, and bulletin board registration, the last furnished by Rinehart News Company, were part of equipment and service.

Joint Annual Meeting for Presidential Addresses, Tuesday Morning, March 15.

Ingredients for Annual Dinner-Dance: St. Patrick's Day Flowers, Chicken Dinner, 10-Piece Orchestra, Floor Show.

ANNUAL DINNER-DANCE, THURSDAY NIGHT, MARCH 17, 1949. SIX HUNDRED ATTENDED.

FRANCIS MAURICE VAN TUYL, honorary member
Colorado School of Mines, Golden

FRANCIS MAURICE VAN TUYL, HONORARY MEMBER[1]

CARROLL E. DOBBIN[2]
Denver, Colorado

Francis Maurice Van Tuyl was born October 15, 1889, in the town of Denmark in the southeastern corner of Iowa. Being a somewhat precocious and, as he states, a mischievous youngster, he ran away *to* school at the age of 3, was told by his teacher that he would be in the penitentiary before he was 21, and matured in a rural laboratory that excited him as a small boy to write about various natural objects—even skunks—and incited him to study geology rather than law at the State University of Iowa.

Van Tuyl received the degrees of B.A. and M.S. at Iowa, and Ph.D. at Columbia. He is a member of Phi Beta Kappa, Sigma Xi, and Tau Beta Pi honorary societies and of many leading scientific and engineering organizations.

Since joining the faculty of the Colorado School of Mines in 1917 and becoming professor and head of the department of geology in 1919, Van Tuyl has seen the total annual registration of students increase from about 100 to 1,200, the full-time faculty members in geology from 2 to 15, and the number of courses in geology from 13 to more than 60. He collaborated in establishing and maintaining the outstanding department of geophysics and a large well-sample depository there; he established the world's first curriculum in geological engineering in 1924; and he has taught, stimulated and guided thousands of students of geology from all parts of the world.

Before coming to Mines in 1917, Van Tuyl was a geologist in the Iowa Geological Survey and a member of the Hudson Bay Exploring Expedition of the University of Illinois. Since then he has been, besides a teacher, author, editor, and researcher, a petroleum geologist in the Mid-Continent, the Rocky Mountain states, and Brazil and an active member of many national geological and engineering committees, especially the research committee of this Association.

Van Tuyl's leading publications treat of the origin and character of dolomite, the stratigraphy of the Mississippian formations of Iowa, the geology of an area near Hudson Bay and James Bay, the physiographic development of the Front Range, the origin, migration, and accumulation of petroleum, and annual developments in petroleum geology. His fifty other publications, likewise treat of diverse geological subjects.

Van Tuyl has always heeded the dictum of ancient Antipho that the greatest of all sacrifices is that of time.

[1] Manuscript received, March 14, 1949.

[2] United States Geological Survey.

GEORGE CLARK GESTER, HONORARY MEMBER[1]

ROY M. BARNES[2]
Los Angeles, California

George Clark Gester, illustrious past-president of The American Association of Petroleum Geologists, was cited as honorary member of the Association on March 15, 1949, at the annual meeting in St. Louis. He is consulting geologist to the Standard Oil Company of California and its subsidiaries and was for twenty-three years chief geologist of that world-wide organization. His headquarters are in San Francisco and his home is in Berkeley, California.

[1] Manuscript received, March 31, 1949.

[2] Continental Oil Company.

GEORGE CLARK GESTER, honorary member
Standard Oil Company of California, San Francisco

Born, June 16, 1884, in Buffalo, New York, Clark, as he is universally known, came to California as a young boy. One of the earliest records of his long and impressive career in the West is attendance at Rattlesnake Bar Grammar School near the site of discovery of gold in California. The degree of Bachelor of Science in Geology and Mining was conferred on him by the University of California at Berkeley in 1909. He instructed in geology and mining at his Alma Mater during his fifth year of residence at the university in 1908 and 1909. Clark's honorary societies are Sigma Xi, Theta Tau, and Phi Lambda Upsilon (chemistry). He played soccer at California where he developed into an outstanding

kicker and bunter; his co-workers state that they have often felt the impact of this kicking and headwork professionally.

From 1909 to 1914 Clark Gester first did land-classification geology for the Southern Pacific Railroad and then worked on oil-development geology for a subsidiary of that company. During this period was laid the foundation for one of the most prominent oil exploration and exploitation careers in the West, a career which later guided exploration in many parts of the world. The years 1914 to 1917 were spent in foreign and domestic consultation. In 1917 he joined the geological staff of the Standard Oil Company of California; he became chief geologist in charge of foreign and domestic work in 1921 and was made consulting geologist in 1944. In these assignments he contributed much time to organization and exploration activities in the Middle East, Dutch East Indies, Mexico, and South America.

Clark Gester's membership in The American Association of Petroleum Geologists dates back to 1920. He was elected vice-president in 1921 and president in 1927. He is an indefatigable worker and wise counsellor in our Association; among the committees on which he has served are Constitution, General, Research, Business, Trustees of Research Fund, and Medal Award. He has given of his untiring self to the welfare of many other scientific and professional societies and to industry organizations; among these are the American Institute of Mining and Metallurgical Engineers, the Geological Society of America, the Pan American Institute of Mining Engineering and Geology, the California Academy of Sciences, and the American Petroleum Institute. He has served on at least six important A.P.I. committees and he is probably best known for his long-time chairmanship and guidance of the Pacific Coast Section of the Reserves Committee. His bibliography of geological and allied petroleum publications is voluminous and substantial.

Clark Gester is responsible for the early training of many, many geologists. It can be truthfully said that, during years spent in corporate, professional, and organization work, Clark has done more to stimulate geologists to hard work, to forward thinking and to greater deeds than any other geologist in the West. This influence is world-wide; his boys are found wherever there is petroleum exploration.

Clark Gester has many avocations. He is a golfer of note and has won numerous prizes. He is still a hardy mountain climber and loves to swim in mountain lakes fed by melting snows. Photography is his hobby and his home is well equipped for following this pursuit. Clark is a very friendly fellow. He loves to entertain informally. He is a teller of tall tales. In spite of these avocations, he is most happy when he is "up to his ears" in work. When he retires from corporate duties he will not become inactive. He will have just that much more time to give to his friends, to his hobbies and most of all to the societies that he has so long, faithfully, and expertly served.

In electing George Clark Gester to honorary membership, The American Association of Petroleum Geologists pays tribute to a most prominent figure in the oil industry, to a world geologist, and to a beloved leader among geologists all over the world.

SHERMAN ALEXANDER WENGERD, RECIPIENT OF PRESIDENT'S AWARD

ELMER W. ELLSWORTH
Tulsa, Oklahoma

The recipient of the President's Award for the most significant original *Bulletin* paper in 1948, by an author under 35 years of age, is Sherman Alexander Wengerd, assistant professor of geology at the University of New Mexico, Albuquerque. President Paul Weaver presented the certificate and $100 at the annual Association meeting, this year on March 15, in St. Louis, Missouri. The prize-winning article, "Fernvale and Viola Limestones of South-Central Oklahoma," was published in the December, 1948, *Bulletin.*

SHERMAN ALEXANDER WENGERD
Recipient of President's Award
University of New Mexico, Albuquerque

Sherman A. Wengerd was born at Millersburg, Ohio. During the summer of 1935, following his junior year at the College of Wooster, Wooster, Ohio, he was engaged in field work in Virginia, gathering material for his graduating thesis, "Geology of Highland County, Virginia." During his senior year he assisted in teaching geology and mineralogy. After a year of graduate study at Harvard University, 1936–1937, Wengerd had his first taste of commercial field work in petroleum exploration during the spring and summer of 1937, when he worked as seismic helper and instrument man for the Shell Oil Company, Inc., Tulsa, Oklahoma. Returning to Harvard University, he received his A.M. degree in geology in June, 1938. That summer he took a job as mining geologist for the Ramshorn Mining Company, Challis, Idaho.

Returning to Harvard University in the fall of 1938, Wengerd served as Austin teaching fellow and instructor in geology at Harvard from 1938 to 1940. All Harvard residence requirements for his Ph.D. degree in geology were completed by July, 1940, when he ac-

cepted a position as geologist with the Shell Oil Company. Engaged in surface and subsurface geological work for the Shell until 1942, he took voluntary military leave in July of that year, and, with the rank of Lieutenant (j.g.), entered upon active duty with the U. S. Navy. Rising to the reserve rank of Lt. Commander during his tour of wartime duty from July, 1942, until October, 1945, Wengerd was engaged in photogrammetric and geodetic engineering and photogeology for the Hydrographic Office, Aerial Survey and Mapping Unit, and U. S. Naval Petroleum Reserves. Including field studies on the Arctic Slope of Alaska, much of his naval service was devoted to photogrammetric work having direct application to the functions of a petroleum geologist. With Norman C. Smith, Wengerd is co-author of "Photogeology Aids Naval Petroleum Exploration," published in the May, 1947, issue of the A.A.P.G. *Bulletin*. This well illustrated paper reports on methods used in the wartime exploration program for Naval Petroleum Reserve No. 4 in northern Alaska.

After $3\frac{1}{2}$ years of service with the U. S. Navy, Wengerd was separated from the service in October, 1945, and the following month re-joined the geological staff of the Shell Oil Company. While engaged as a Shell research geologist during the next 2 years, he prepared his Ph.D. thesis, and his doctorate in geology was conferred by Harvard University in 1947. The paper which won the President's Award is based on this doctoral thesis. Wengerd resigned his geological position with the Shell Oil Company in the fall of 1947, in order to accept appointment as assistant professor of geology at the University of New Mexico, which position he now holds.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 772-780, 4 FIGS

MEMORIAL

ROY EDWARD COLLOM
(1881–1948)

In the passing of Roy Collom on September 25, 1948, the oil industry lost a brilliant executive and the geological profession feels the absence of a willing worker and a staunch supporter.

Roy Edward Collom was born at Golden, Colorado, December 13, 1881, the son of Martin H. and Augusta Bruce Collom. His father died in August, 1946, and his mother still resides in Denver. Roy was married in February, 1912, at Hanford, California, to Yetta Florence Erhardt of an early California family; "Sally" Collom resides at the family home in Glendale, California. Their three children, all married, are Dorothy (Mrs. R. W. Horstman) now in Switzerland, Bruce Baily of Burbank, California, and Edward Vincent who resides in Alameda, California. Six grandchildren who are often at the family home made Roy's life strenuous but happy.

After graduation from East Denver High School in 1899, Roy Collom studied at Colorado School of Mines and transferred to Stanford University where he graduated with an A.B. degree in geology and mining in 1906. His graduation exercises consisted of rendering service to those stricken by the April, 1906, earthquake and fire in San Francisco. Roy has told many interesting stories of his experiences and of events during and after that disaster.

During the first 4 years following graduation from Stanford, Roy engaged in various mining activities. As have many other prominent California oil men, he transferred from mining to oil by starting work in the oil fields at Coalinga, California in 1910. In 1915, after learning the hard way on a variety of oil-field and pipe-line jobs, he became petroleum engineer at Taft, California, for the newly organized State Mining Bureau, Department of Petroleum and Gas. In 1916 he was appointed deputy State oil and gas supervisor for that department at Santa Maria and in 1918 he became chief deputy with headquarters in San Francisco. These State assignments were during the formative years of the Department of Petroleum and Gas (now Division of Oil and Gas of the State Department of Conservation) and Roy Collom and his chief, R. P. McLaughlin, had a major part in building the solid foundation from which this State agency administers conservation of California's oil and gas resources.

Roy left State service in 1919 for 1½ years with the United States Bureau of Mines in various special assignments and supervisory capacities. In January, 1921, he returned to the Department of Petroleum and Gas as State Oil and Gas Supervisor. Here followed nearly 3 years of building this conservation agency on the solid foundation established by Roy and his co-workers in the formative years.

The Marland Oil Company, which had recently entered California, enticed Roy Collom from State service in October, 1923, to be its chief geologist on the West Coast. After 3 years as chief geologist, vice-president and director, and 2½ years as executive vice-president of the Marland Oil Company of California, he became manager of California operations for the Continental Oil Company which was the successor to Marland in California. Following a short period away from California as assistant to the president of the Continental Oil Company, he became its vice-president in charge of all western operations in 1933 and continued in this capacity until retirement in December, 1946. As an executive of the Continental Oil Company Roy Collom took a leading part in the formation of Kettleman North Dome Association. He was on Kenda's board of directors from

ROY EDWARD COLLOM

inception in 1930 and was president of K.N.D.A. from 1934 until his death. In these long assignments he exercised the same technical know-how, sound judgment, and integrity which he applied to his State service and he is largely responsible for the place of each of these organizations in California's petroleum industry.

Roy Collom was a long-time director of the California Oil and Gas Association (now Western Oil and Gas Association) and was president in 1940 and 1941. He was also a pillar of P.A.W. Production Committee for District No. 5 during World War II.

Roy Collom's membership in the American Association of Petroleum Geologists dated back to 1919. He was one of its active "old-timers." He was on the committee which formed the geological society that soon after became the Pacific Section of the American Association of Petroleum Geologists. He was also a member of the American Institute of Mining and Metallurgical Engineers, Geological Societies of American Universities, and the American Petroleum Institute. He was a member of the California Club, Jonathan Club, and Los Angeles Athletic Club. Roy showed a keen interest in all young geologists and engineers. He contributed his counsel to the Stanford Geological and Mining School and he was an active sponsor of the Ralph Reed Memorial Geological Library at the University of California at Los Angeles. He found time to write and publish many technical and operational articles relating to the oil industry.

In spite of Roy's active professional and business career he spent much time with his family in his home and garden and on camping trips. He was a lover of the outdoors. His garden, to which he lured a great variety of native birds, and for all of which he could give their common and scientific names, contained many unusual trees, shrubs, and plants, but his greatest interest was in rare cacti and succulents. He was also an avid sportsman who enjoyed fresh- and salt-water fishing and hunting. His take of fish and bag of game from dove to deer has always been the envy of his less fortunate brother sportsmen.

The story of Roy Edward Collom parallels that of the California oil industry in which he was so active during its constructive period. Individually and collectively we mourn the all too early death of one of its hardest workers and wisest counsellors. Personally we have lost a fine companion and a true friend.

Roy M. Barnes

Los Angeles, California
February 25, 1949

ARTHUR RAYMOND MAY

(1893–1948)

Arthur Raymond May died on December 9, 1948, in Los Angeles. The end came suddenly as a result of a heart attack, while he was in the Jonathan Club. He had suffered a similar attack several years before but made a good recovery and for a long time had been carrying on normal work. Lately he seemed to be in good health and his passing was therefore a decided shock to all his friends. Funeral services were held in Bakersfield on Monday, December 13. Interment was in the Greenlawn Cemetery there.

He was the son of George Arthur May and Annie Laura (Noyes) May, born at Nipomo, San Luis Obispo County, California, on February 26, 1893.

His early education was in the grade schools of Nipomo and later he attended the Santa Maria Union High School from which he graduated in June, 1911. In 1913 he enrolled in the College of Mining in the University of California and graduated with honors in 1917. After this he spent a year in graduate work in the geological department at Berkeley, receiving the degree of Master of Science. During this year he held a teaching fellowship in the department of geology. The work of the university in 1917–1918 was disturbed by changes arising from the entry of the United States into the first World War and in April, 1918, Art joined the United States Navy where he remained until the end of 1918.

In February, 1919, he entered the service of the Shell Company of California. He remained with that company or other companies of the Shell group until March 31, 1939, and during this 20-year period he worked over much of the western United States. In 1921 and 1922 he went to Ecuador and Peru on an exploration trip. It was after this experience that those who knew him best fell into the habit of addressing him as "Arturo." Returning to the United States, he worked in various areas in California, finally arriving

in the South San Joaquin Valley where he became district geologist with headquarters at Bakersfield. He occupied this position from 1924 to 1936. From 1936 to 1939 he worked in the Los Angeles office of the Shell Oil Company as assistant to the chief geologist. During 1934 he spent 6 months on European leave. During this period he visited Roumania and also worked for a time in the offices of the Royal Dutch Shell in The Hague.

Shortly after leaving the Shell group he joined the Superior Oil Company on April 25, 1939. From 1939 to 1944 he was assistant chief geologist, working for the most part in California. However, in 1940 he visited New Zealand to investigate the holdings of the Superior Oil Company there and in 1943–1944 he visited the Bahamas where the Superior Oil Company was interested. In 1944 he became chief geologist of the Superior Oil Company for California which position he occupied until the time of his death.

He was a member of the American Association of Petroleum Geologists, the Society of Economic Paleontologists and Mineralogists, the American Association for the Advancement of Science, and the Seismological Society of America. While in the university he was elected to two nationally known honor societies: Tau Beta Pi and Theta Tau.

Arthur Raymond May

On May 27, 1922, he was married to Lucille Ynez Brown of Santa Maria. Later they established their residence in Bakersfield and continued to maintain their home there until the present. His wife, who graduated from the University of California Medical School in 1924, established her practice in Bakersfield and became one of the best known physicians of that region. Their only son, Robert, now 19 years of age, was born in Bakersfield. Arturo was always devoted to his family and his home and was especially proud of his wife and her achievements in her profession.

He made the search for new oil fields his specialty and in that specialty he had a considerable degree of success. Many people spoke of him as being lucky, but in his case at least, luck was merely the willingness to tackle his problems, work diligently, and to organize his work with minimum waste of effort. Above all, he possessed the natural ability to observe accurately and think clearly in reaching his conclusions. While he had a reasonable degree of caution when working with new or untested methods, he certainly was never afraid of new ideas and was always searching for, and willing to try out, some new and different method of attack on his problems. As an example, early in 1922 he became interested in the possibility of using microfossils in the study of subsurface problems and although not an expert paleontologist, he persisted with his studies until he succeeded in

making very practical use of this method of correlation. As a matter of fact, he was one of the two men in the Shell Company to whom credit must go for first making practical application for that Group, of the art of using microfossils as stratigraphic markers. This, incidentally, was at a time when almost all geologists, and most paleontologists as well, thought such efforts to be hopeless. Even though in later years his administrative duties took him away from direct participation in the work of the microfaunal section, he still carried on these studies in his spare time and gradually built up a very large collection of foraminifera. This collection with his notes on it is now serving a very useful purpose in the construction at the University of California at Berkeley.

During his years of work, Art had supervision over many men and a large number of geologists now active in California and elsewhere can look back with gratitude to the careful training in geologic methods and to the encouragement and inspiration they received from him as they were beginning their practical experience.

He was popular with his associates in the field. He was always cheerful and there never seemed to be an occasion when the going got a little rough that Arturo could not bring the situation back in balance by some quaint comment on the cause of the difficulty—be it brush, temperature, or insects! With his other interests he included an enthusiasm for fishing and, as in other things, he was most proficient in this sport and could always manage to bring out fish if any were there, while others were wondering just how he did it. He was also much interested in football and followed the fortunes of the California team very closely.

Those of us who have had the privilege of working with him will always be grateful for his assistance and unfailing support in our common effort. He will long be missed, but there will remain for us the memory of many days passed pleasantly in the field, the friendly discussions of the problems encountered, as well as the occasional rejoicing over the success of some venture in which we were involved.

E. FRED DAVIS

Los Angeles, California

FLOYD CUMMINGS DODSON

(1895–1949)

Floyd Cummings Dodson died at his home, 219 West Harris Street, San Angelo, Texas, on the morning of January 29, 1949. The cause of death was cancer.

Floyd Dodson, son of John Freeman Dodson and Alice Cummings Dodson, was born on a ranch in Concho County, Texas, on August 31, 1895. He was graduated from the public school of Paint Rock and the Big Spring High School. He lost his right arm as the result of a hunting accident in his early youth. Handicapped in a way that would have discouraged many, his ardor was not dimmed. He lettered in track at the University of Texas, and also participated in various intramural sports, including basketball, swimming, handball, and gymnastics. His love of sports continued throughout life. His prowess as a hunter and fisherman is legendary.

He studied geology at the University of Texas, receiving his B.A. in 1920. Active in student affairs, he was a charter member of Zeta Chapter of Sigma Gamma Epsilon. He worked his way through school. During summer months he was employed by the Texas Bureau of Economic Geology and the United States Geological Survey.

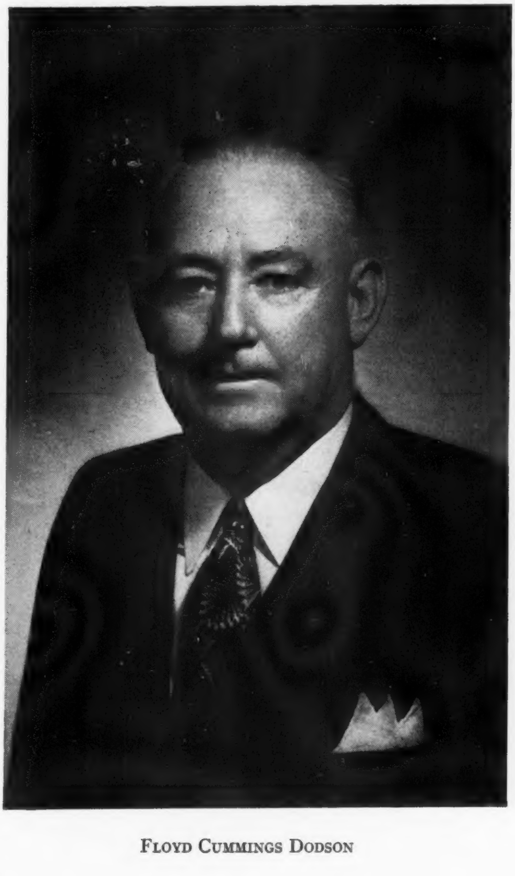
He was married on September 12, 1922, to Lera Johnson, who survives him. They had three children who also survive. These are Floyd Cummings Dodson, Jr., senior at the University of California, Dwain Freeman Dodson, senior pre-medical student at the University of Texas, and Mrs. Carolyn Dodson Dudley, all of San Angelo. There is one grandson, Walter Dodson, son of Floyd, Jr.

Floyd Dodson was a pioneer in the study of the petroleum geology of the Permian

basin of West Texas. He started his professional career as a consulting geologist at Big Spring in 1921, moving to San Angelo in January, 1925, as a member of the firm of Ricker and Dodson, who were retained by many companies and individuals in the rapidly expanding exploration program in the area. Floyd Dodson's optimistic evaluation of the significance of early oil discoveries is well remembered by those who retained him and also by the many friends with whom he cheerfully shared his concepts. His influence, too, went into the organization of geological departments for companies that retained him. Through younger men whom he selected to hold positions of trust and responsibility his comprehensive views are widely spread.

During later years he devoted an increasing effort in directing attention to the oil possibilities of the area surrounding his home town of San Angelo. It is a happy thought that he lived to see several oil fields opened in the vicinity.

Floyd Dodson gave time and effort to the problems of society. He was a member of the Methodist Church, the American Association of Petroleum Geologists, the West Texas Geological Society, the "T" Association of the University of Texas, and Sigma



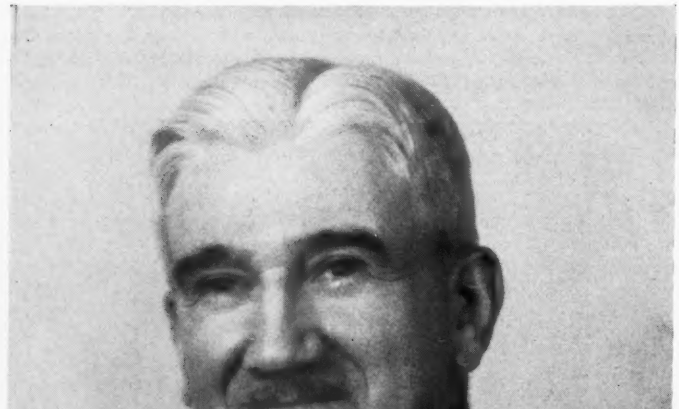
FLOYD CUMMINGS DODSON

Gamma Epsilon. To all of these he was at all times ready to participate in the solution of their problems. His method of approach was informal. With a smiling face, a twinkling eye, and a witty expression he was able to present a cheerful and optimistic view. His mind was clear, his friendship warm, and his feeling of good will unbounded.

. R. L. Cannon

San Angelo, Texas
March 29, 1949

CHARLES WILLIAM HONESS
(1885–1949)



Charles William Honess

Charles William Honess was born in Berea, Ohio, June 28, 1885, and died in Evansville, Indiana, March 29, 1949. His death followed by a few hours an operation for the removal of a brain tumor, after an illness of short duration. He is survived by his wife of Evansville, a daughter, Mrs. Ira Osman, and granddaughter, Alice Margaret of St. Louis, and a brother, Leon Honess of Angola, Indiana, the family home where Charles was buried. He was a brother of the late Arthur P. Honess, professor of mineralogy and petrology at the Pennsylvania State College. His father was born near Dover, England, and his mother in Bedford, Ohio, both being of English ancestry. He was married to Lydia Savelle on June 6, 1931, in Tulsa, Oklahoma.

Charles started in grade school in Berea, Ohio, and finished in a "Little red school house near Ellis, Indiana," to use his own words. He graduated from the Angola, Indiana, High School in 1908 and from Oberlin College in 1912. In 1913 he received his A.M. degree from Cornell and in 1923 his Ph.D. from Columbia. He was a charter member of the American Association of Petroleum Geologists, Fellow of the Geological Society of America, Fellow of the American Association for the Advancement of Science, and member of the Society of Economic Paleontologists and Mineralogists. He was a member of Sigma Xi and Sigma Gamma Epsilon. He received a university scholarship from Cornell and a university fellowship from Columbia. He was the author of several publications, principally on the geology of Oklahoma, while associated with the Oklahoma Geological Survey.

Dr. Honess spent the summer of 1914 with the Wisconsin Geological Survey occupied with the classification of mineral lands. For seven years, 1916 to 1923, he was with the Oklahoma Geological Survey, engaged most of this time with geological field mapping.

He was with the Empire Gas and Fuel Company, now Cities Service, from 1923 to 1927 as a petroleum geologist, and in 1927 joined the geological department of the Gulf Oil Corporation, with which he was associated at the time of his death. During his twenty-two years with Gulf he served in Oklahoma and Kansas and for the past several years as district geologist in Kentucky and Indiana.

The Association has lost a member who was on all occasions a credit to his profession. He was loved and admired by his many friends, and Charles Honess had no enemies. W. I. Ingham, who was associated with him in recent years, said "He was one of the finest men I ever knew or worked with—considerate, modest, and unassuming—a gentlemen and a scholar. As you know, everyone liked Charlie and we will miss him very much." His interests were not confined to his profession. In the long list of scientific subjects he studied during his college days and in later life he included art, music, history of philosophy, psychology, and the Bible.

WILLIAM R. LONGMIRE

Tulsa, Oklahoma
April 18, 1949

JAMES FULTON SWAIN
(1903–1948)

The untimely death of James F. Swain occurred during the early evening of October 4, 1948. He was returning to Pittsburgh, Pennsylvania, from western Virginia in a private plane which crashed and burned in the rugged terrane of western West Virginia 40 miles north of Charleston. This unhappy event threw a pall over the regional meeting of the American Association of Petroleum Geologists which was in progress at the William Penn Hotel in Pittsburgh. An urgent geological investigation had taken Mr. Swain to Virginia and he was hurrying back to this meeting at which he was scheduled to deliver a paper the following morning.

Thus was brought to a close in its burgeoning one of the most promising careers in the profession. "Jimmy" Swain was small of stature but as vital as a giant. His wit was as keen

as a Toledo blade. He gave to the science of geology the devotion of a true disciple and he brought to the altar of that devotion a candle of intelligence that cast its brilliance far and wide.

James Fulton Swain was born in Dillonvale, Jefferson County, Ohio, August 20, 1903. He moved, with his family, to Wilkinsburg, Pennsylvania, a suburb of Pittsburgh, in 1912. He attended grade and high school in Wilkinsburg. Blessed with an excellent baritone singing voice he won a scholarship at Washington and Jefferson College in Washington, Pennsylvania. While he continued to sing with the various musical organizations in that institution, he did not enroll in the School of Music but, instead elected a course in civil engineering which he pursued for two years. Because he was under the necessity of financing his college education from his own earnings and could secure part-time work in the city of Pittsburgh, he transferred to Carnegie Institute of Technology at the beginning of his junior year of undergraduate work. Lack of adequate finances, however, forced him to drop his studies before the school year was finished and his formal education ended at that point.

During that part-year in Carnegie Tech, Mr. Swain took an elective course in geology and, for him, the grail was found. The calibre of the man is attested by the fact that during the next twelve years, by his own efforts and working alone, he achieved a proficiency in his chosen profession which won for him the respect and acclaim of every geologist who had occasion to become acquainted with his work.

Perhaps because of his training in engineering, Mr. Swain was a clear incisive thinker. He had an unusual ability to carry in his alert mind a regional picture cleanly and completely etched and, at the same time, to meticulously ferret out a multitude of local details and fit them accurately into the larger pattern. His intellectual integrity would not brook compromise with fact. He had imagination, but with him congruence was a passion and any hypothesis must unequivocally meet the test of every fact within his knowledge. By the same token he would revise any hypothesis immediately and unhesitatingly if some fact were discovered which failed to support the hypothesis. A fact, however, had to be a fact, and his ability to distinguish between validity and invalidity of information was developed to a high art.

On September 22, 1932, Mr. Swain was married to Veda C. Book and to this happy and devoted union were born a daughter, Rebecca, who is 14 years of age and a son, James F., Jr., who is 12 years of age: these three survive.

Mr. Swain at the time of his death was engaged in consulting geological work and was a partner of Huntley and Huntley. He was active in the Pittsburgh Geological Society, the Engineers Society of Western Pennsylvania, and the Eastern Section of the Production Division of the American Petroleum Institute.

He made hosts of friends wherever he went. He has bequeathed to them not only the glowing memory of his comradeship but also the invigorating influence of his conviction that accurate thinking was the key to every geologic problem.

M. G. Gulley

Pittsburgh, Pennsylvania
April 5, 1949

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 33, NO. 5 (MAY, 1949), PP. 781-782

AT HOME AND ABROAD

NEWS OF THE PROFESSION

T. K. KNOX, age 52 years, former vice-president and chief geologist of the Republic Natural Gas Company, died in Dallas, Texas, March 7.

A. F. HOTTINGER has moved from the Caribbean Petroleum Company at Caracas, Venezuela, to B. P. M., Soerabaja, Java.

R. B. SULLIVAN, JR., has left the British American Oil Producing Company to join the Sunray Oil Corporation, Shreveport, Louisiana.

SAM N. WEBB, formerly with W. C. McBride, Inc., is with the Honolulu Oil Corporation, Jackson, Mississippi.

JAMES A. CULBERTSON, senior subsurface geologist with the Colombian Petroleum Company, Cucuta, Colombia, has been appointed as geologist in charge of the geological department for the company, succeeding JAMES W. BOWLER who was transferred to Cairo, Egypt, by Socony.

RALPH E. McMILLEN, formerly geophysical supervisor for the Phillips Oil Company in Venezuela, is now chief geophysicist for Phillips in Venezuela and Colombia. McMillen is located in Caracas, Venezuela.

OPAL MARIE LACKIE, consulting geologist of Los Angeles, California, died on March 19, after a cerebral hemorrhage. Mrs. Lackie was 43 years of age.

CHARLES WILLIAM HONESS, of Evansville, Indiana, died March 29, at the age of 63 years. He had been in the employ of the Gulf Oil Corporation since 1928.

ALFRED SENN, of the British Union Oil Company, Ltd., Bridgetown, Barbados, British West Indies, died on January 29, after a surgical operation, at the age of 49 years.

GEORGE W. LA PIERE, consulting geologist and engineer, has moved his office from the Subway Terminal Building to 537 General Petroleum Building, Los Angeles, California.

PAUL E. M. PURCELL announces Purcell Exploration Service, 1125 Hamilton Building, Wichita Falls, Texas.

ED. GRIBI recently graduated from Stanford University and is *en route* to Dire-Dawa, Ethiopia, as a geologist for the Sinclair Petroleum Company.

WALTER H. BUCHER, A.A.P.G. lecturer, addressed the following California geological societies on the subject "Fault Patterns and Fault Movements": A.A.P.G. Pacific Section, Los Angeles, March 31; Coast Geological Society, Santa Barbara, April 1; San Joaquin Geological Society, Bakersfield, April 4; Northern California Geological Society, Berkeley, April 5.

TOM McGLOTHLIN, consulting geologist, announces the opening of his offices in the Fuller Building, Laurel, Mississippi.

S. W. LOWMAN of the Shell Oil Company, Houston, Texas, spoke before the Shreveport Geological Society, April 4, on "Sedimentary Facies of the Upper Cenozoic and Recent Deposits in the Gulf Coast."

KING V. SCHROEDER, of the Sun Oil Company, Beaumont, Texas, spoke on "The Egan Field, Acadia Parish, Louisiana," at the meeting of the Houston Geological Society, April 4.

JOSEPH A. SHARPE, vice-president of the Frost Geophysical Corporation of Tulsa, spoke in Midland, Texas, March 31, at the invitation of the West Texas Geological Society on the topic "Aeromagnetometry—A Primary Reconnaissance Tool for West Texas."

WALTER J. OSTERHOUDT has resigned from the Gulf Oil Corporation, Houston, Texas, and will maintain consulting headquarters in Houston, and in Chromo, Colorado.

WILLIAM H. CURRY has resigned as district geologist for the Atlantic Oil and Refining Company in the Rocky Mountains, to become vice-president and director of the Wy-Tex Oil Company, San Antonio, Texas. He will have his office in Casper, Wyoming.

NORMAN C. SMITH, formerly geologist with the Humble Oil and Refining Company at Tallahassee, Florida, has set up the Western Photo-Geological Company at 811 South Boulder, Tulsa, Oklahoma.

WALTER H. MADDOX may be addressed in care of the Superior Oil Company of Venezuela, Apartado 48, Caracas, Venezuela.

HORACE R. BLANK has resigned from the faculty of Southwestern University at Georgetown, Texas, and has joined the faculty of Texas A. and M. College, College Station, Texas.

HOYT RODNEY GALE is teaching geology at Pasadena City College, California.

ROBERT D. GARRETT is geologist for the Producers Pipe Line Company, Owensboro, Kentucky.

RUSSELL E. HAYWARD has changed his address from Glendale, California, to Apartado Nacional 1140, Bogota, Colombia.

J. C. HEGGBLOM is with the Mozambique Gulf Oil Company, Lourenco Marques (Mozambique), Portuguese East Africa.

PAUL B. WHITNEY is special assistant to the director of the Oil and Gas Division of the United States Department of the Interior, Washington, D. C.

S. A. KERR has resigned from the Imperial Oil, Ltd. He is now employed by the Home Oil Company, Ltd., as geologist. His address is 124th Street, Edmonton, Alberta, Canada.

Effective April 1, J. M. KIRBY will be headquartered at 1818 Canal Building, New Orleans, Louisiana. For the past three years Kirby has served as exploration superintendent of the western division of the California Company, with headquarters in Denver, Colorado.

H. DONALD CURRY, geologist for the Shell Oil Company in Los Angeles, spoke on "Some Structural Features of Death Valley," with color slides, before the Pacific Section of the Association, April 7.

WALTER STALDER, consulting geologist of San Francisco, California, died in March. His age was 67 years. He joined the Association in 1922.

GEORGE HARRIS presented "Geologic Notes on Recent Smackover Development in South Arkansas," at the regular meeting of the Shreveport Geological Society, Shreveport, Louisiana, April 18.

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Monthly meetings. Visiting geologists are welcome.

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Meetings will be announced. Visiting geologists and friends are welcome.

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Meetings will be announced.

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Regular Meetings: 7:30 P.M., Geological Room, University of Wichita, first Tuesday of each month. Noon luncheons, first and third Monday of each month at Wolf's Cafeteria. The Society sponsors the Kansas Well Log Bureau, 412 Union National Bank Building, and the Kansas Well Sample Bureau, 137 North Topeka. Visiting geologists and friends welcome.

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Shawnee

Meets the fourth Thursday of each month at 8:00 P.M., at the Aldridge Hotel. Visiting geologists welcome.

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Editor - - - - - - - - - - - John C. Maher
U. S. Geological Survey, Federal Building

Business Manager - - - - - - - V. L. Frost
Ohio Oil Company, Thompson Building

Meetings: First and third Mondays, each month, from October to May, inclusive, at 8:00 P.M., University of Tulsa, Lorton Hall. Luncheons: Every Friday (October-May), Chamber of Commerce Building.

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Stanolind Oil and Gas Company
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Luncheons: Each week, Monday noon, Blackstone Hotel.

Evening meetings and programs will be announced. Visiting geologists and friends are welcome.

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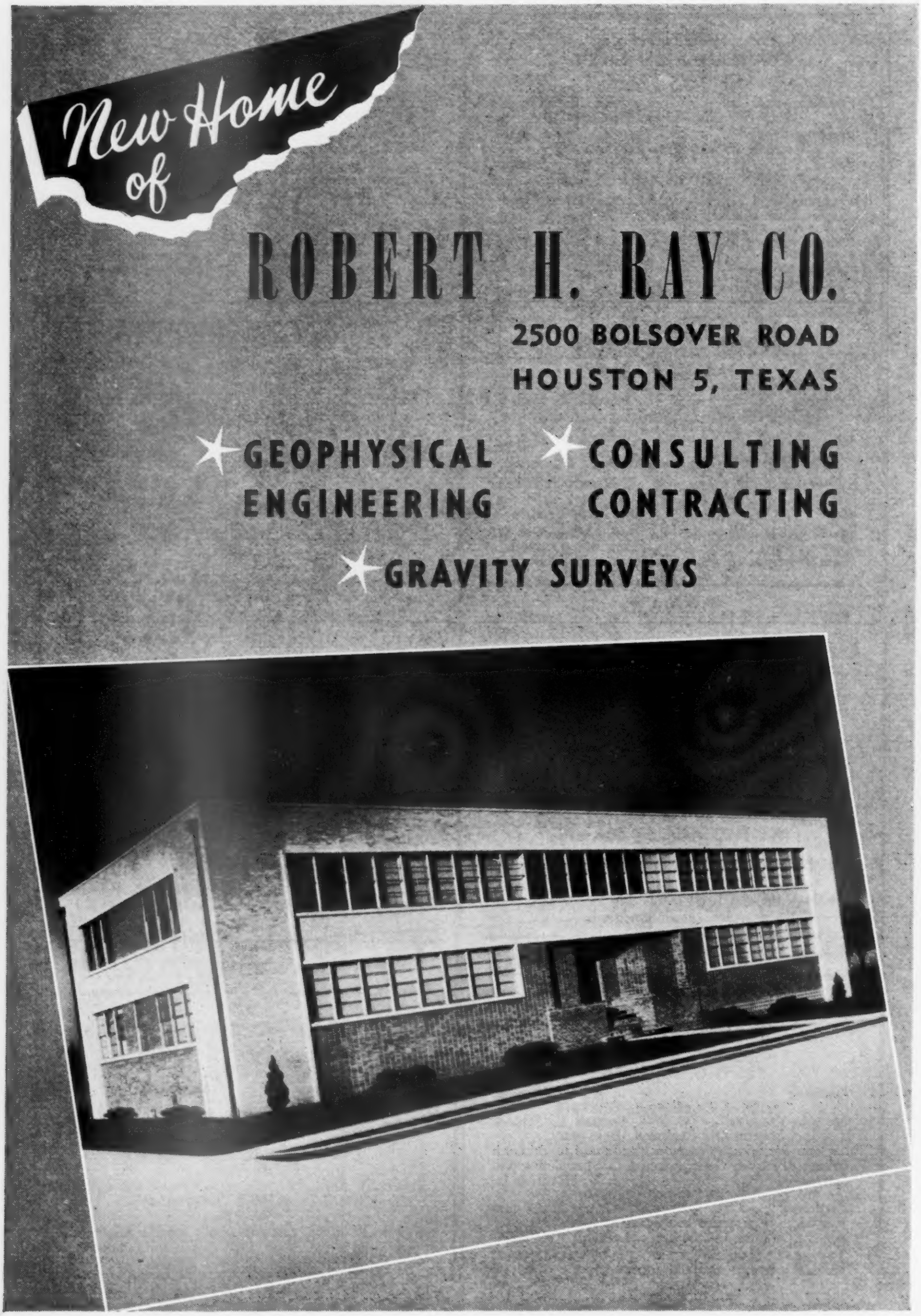
Meetings: Luncheon at noon, Hotel Texas, first and third Mondays of each month. Visiting geologists and friends are invited and welcome at all meetings.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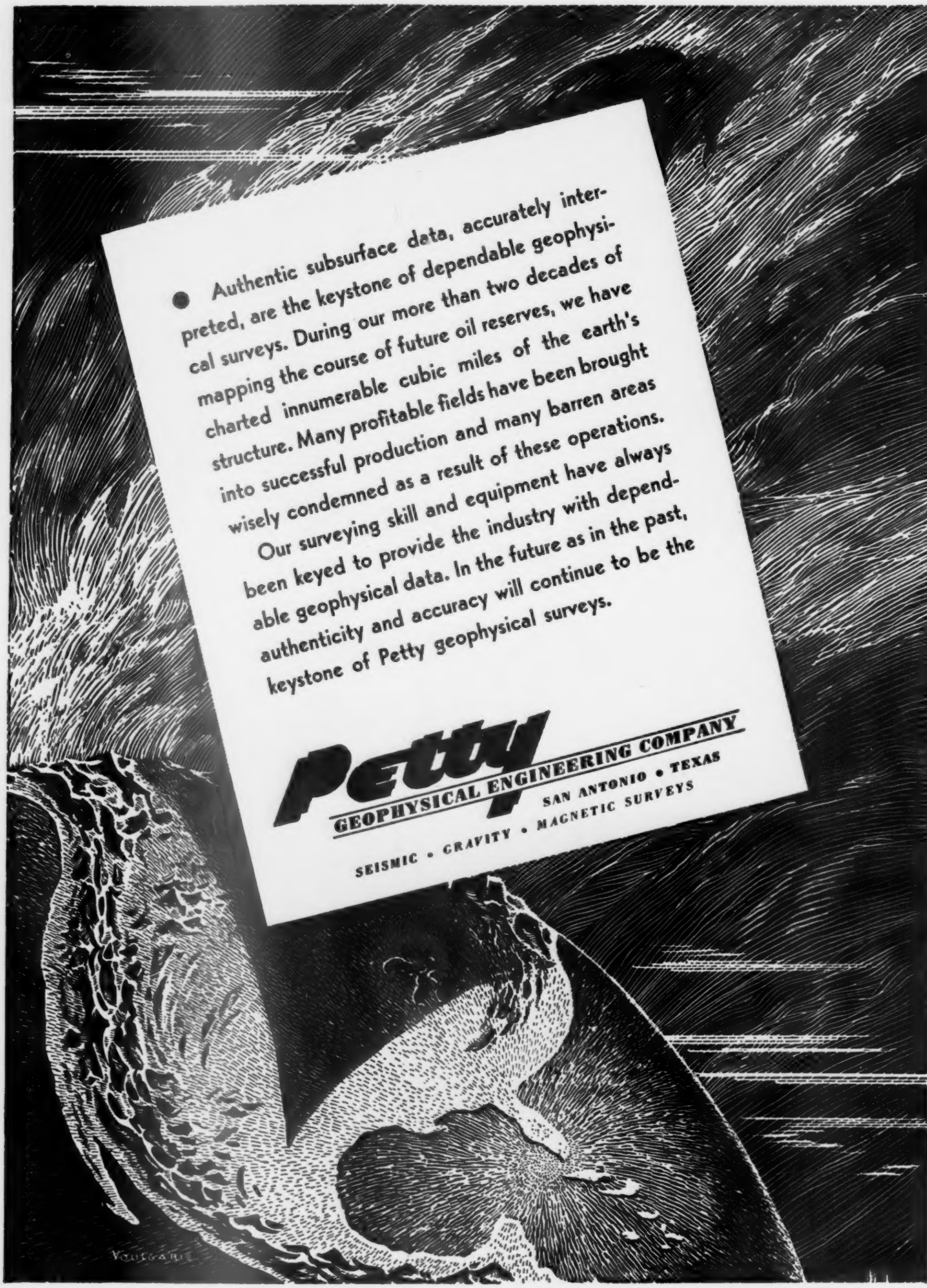
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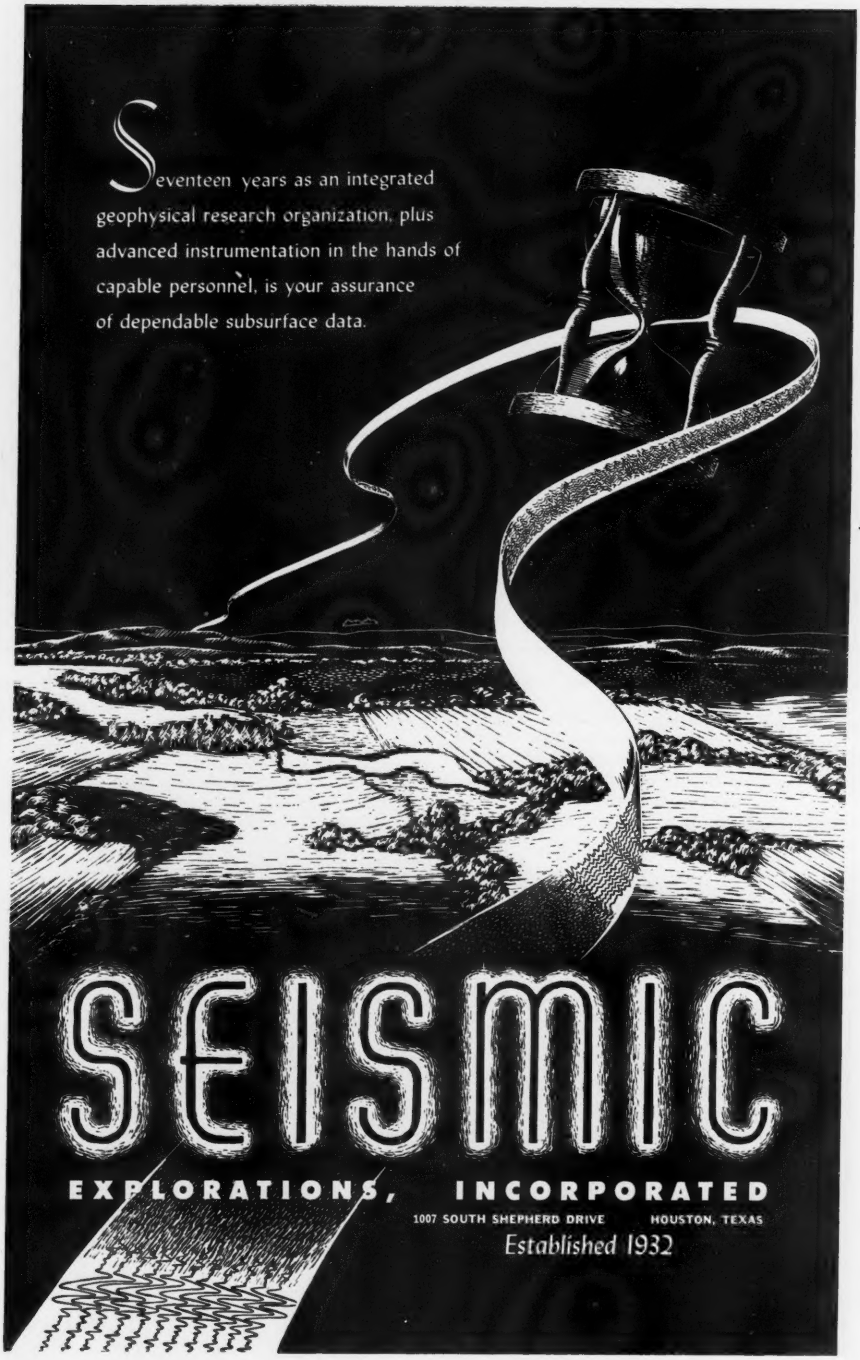
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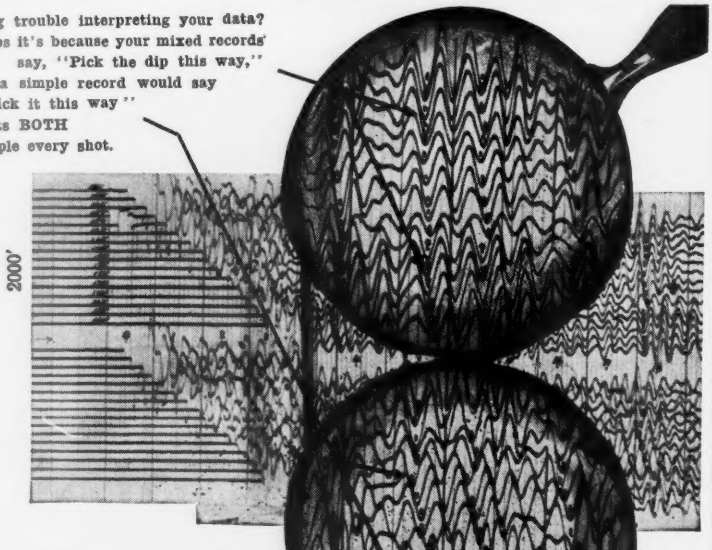
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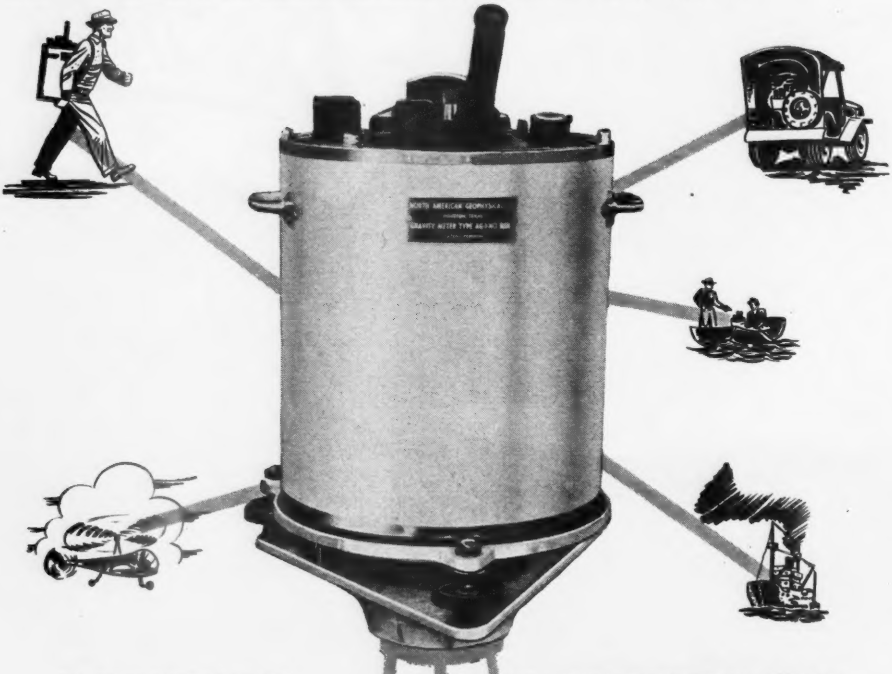

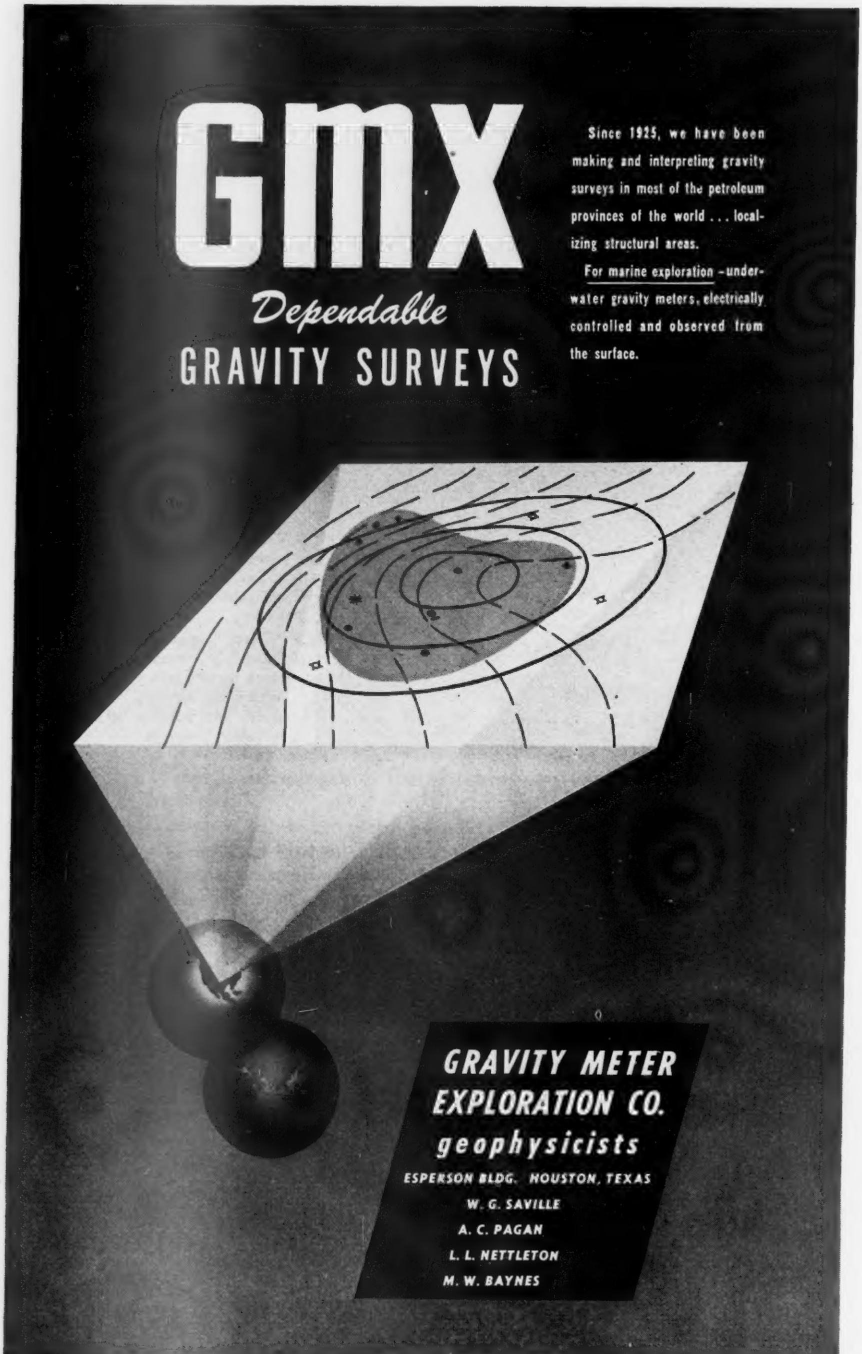
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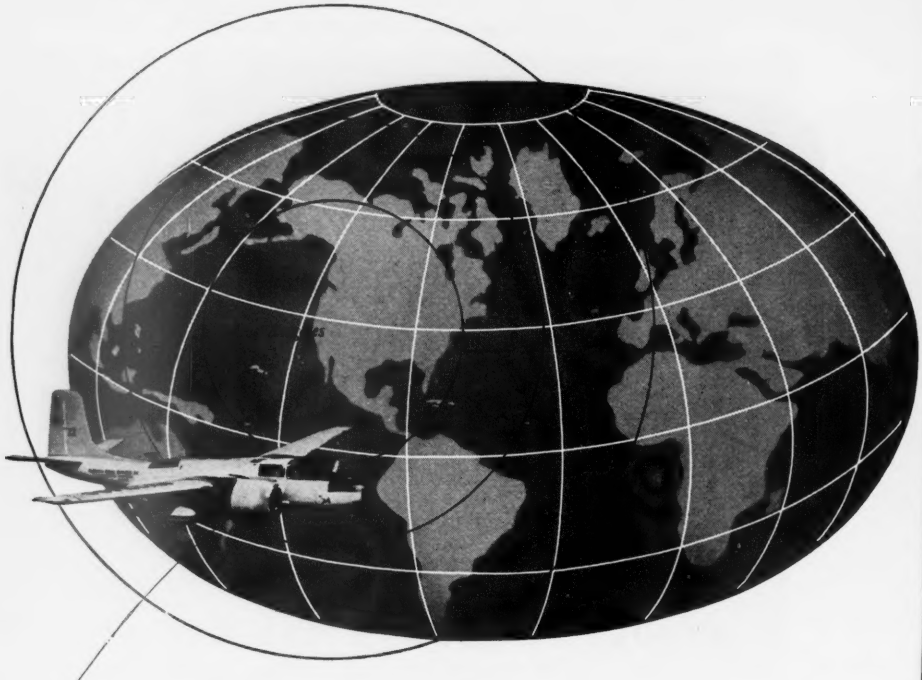


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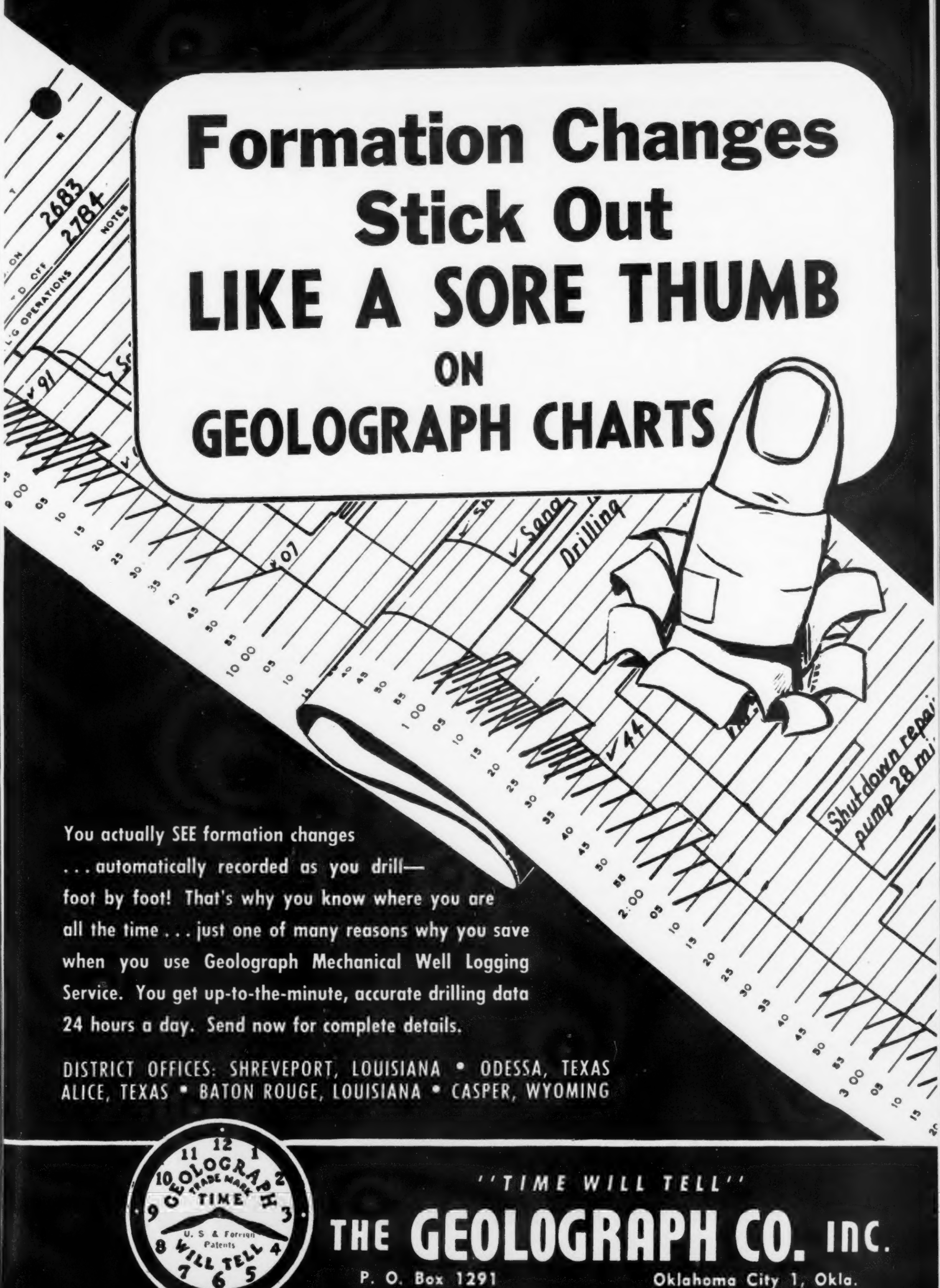

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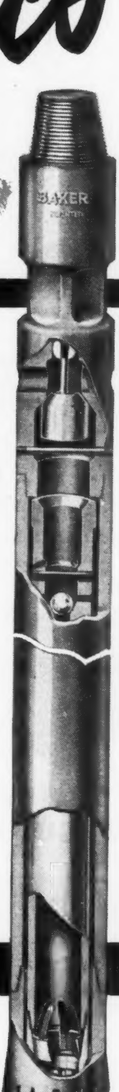
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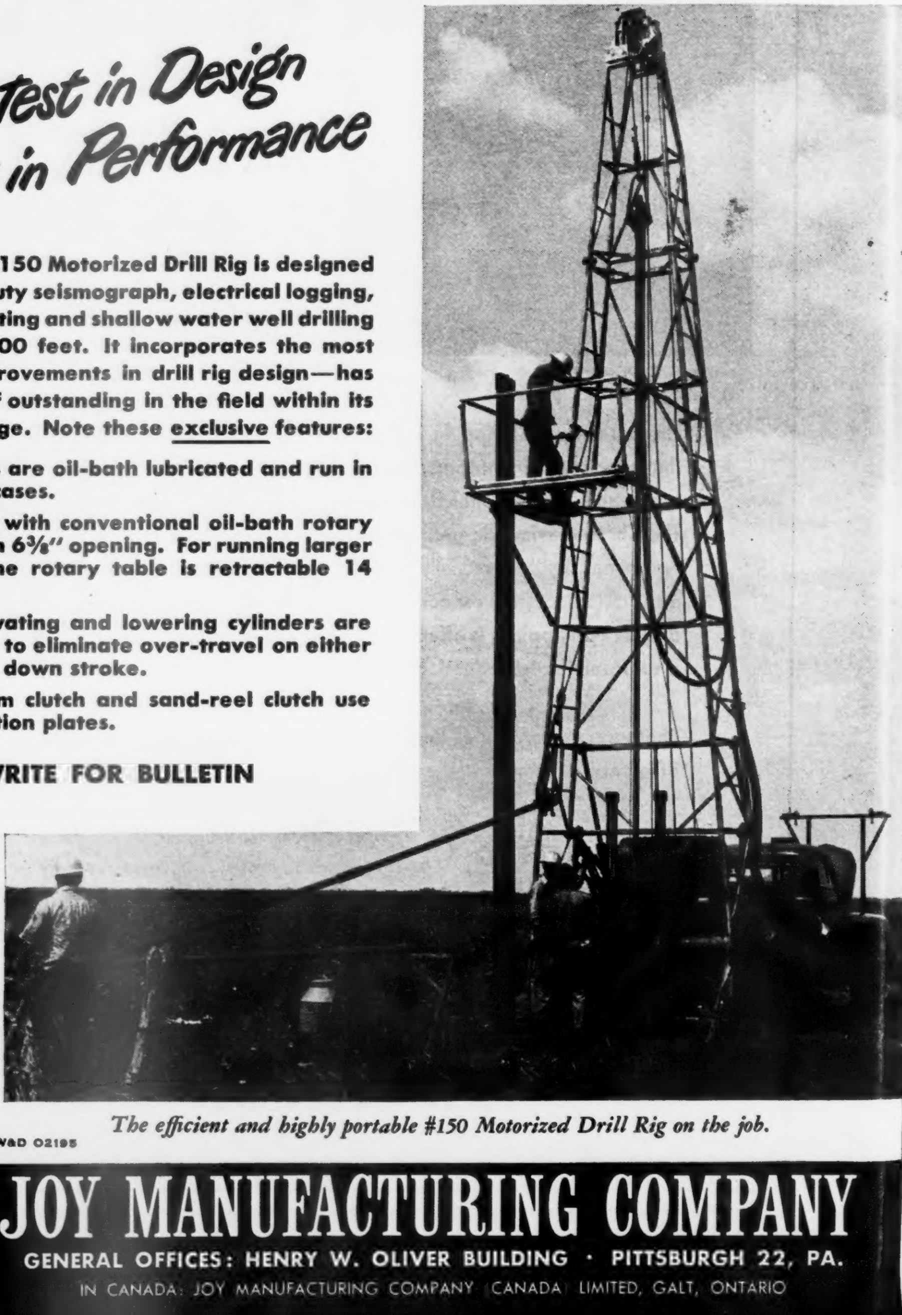

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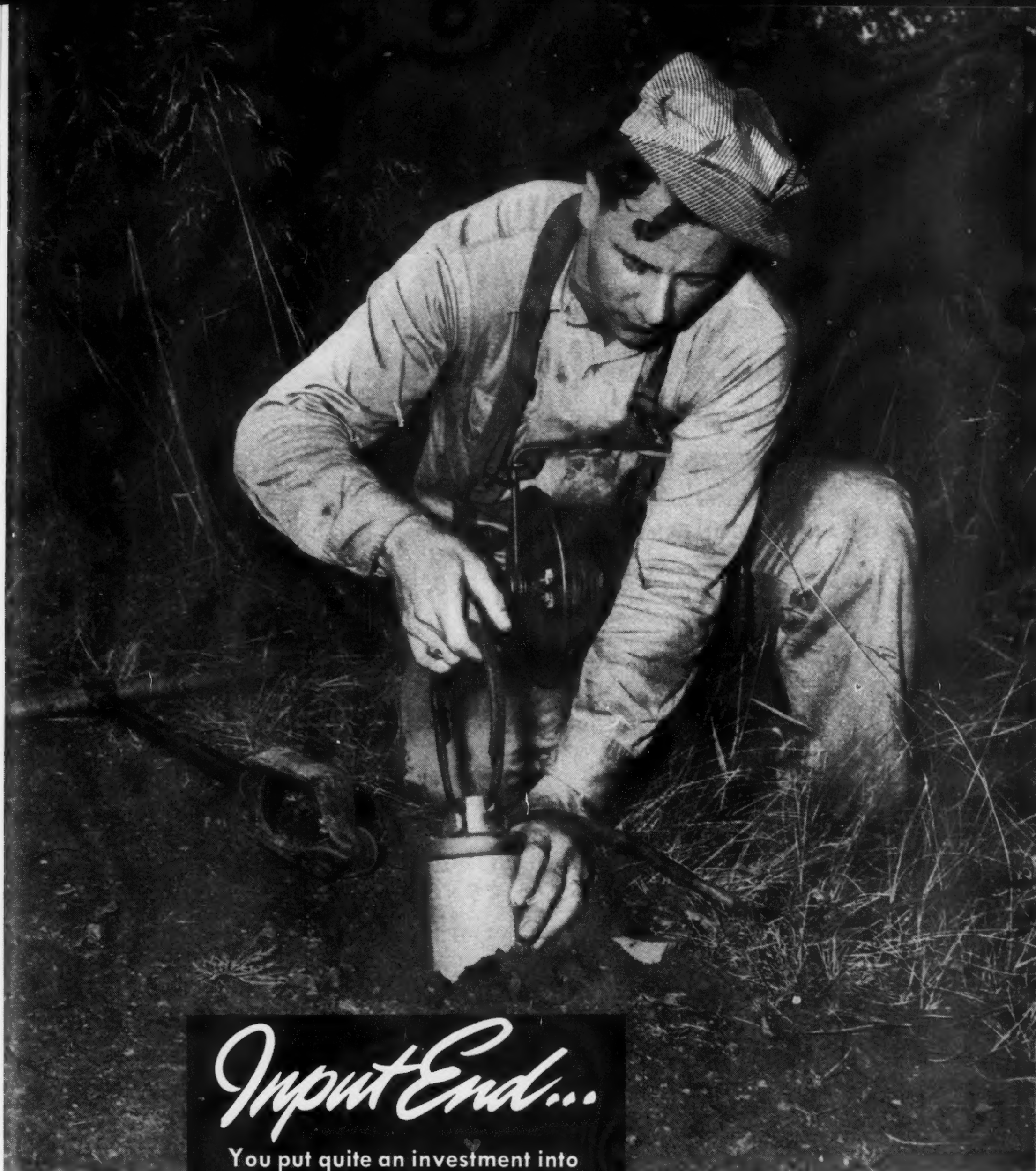

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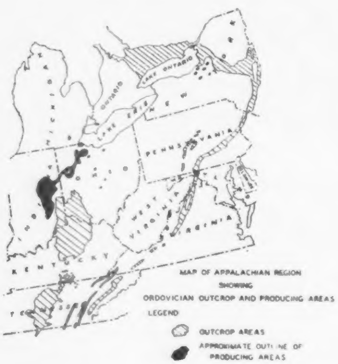
Papers read at the Meeting of the Pittsburgh Geological Society at Pittsburgh, Pennsylvania, May 16, 1947, and published in the Bulletin of the American Association of Petroleum Geologists, August, 1948.



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